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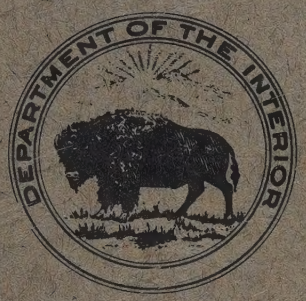
The PROGRESSIVE FISH-CULTURIST

Vol. 10 No. 2



APRIL 1948

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

PROGRESSIVE FISH-CULTURIST

Issued by
UNITED STATES DEPARTMENT OF THE INTERIOR - - - - - - - JULIUS A. KRUG, SECRETARY
FISH AND WILDLIFE SERVICE - - - - - - - - - - - - - - ALBERT M. DAY, DIRECTOR
Printed with the approval of the Bureau of the Budget
Vol. 10, No. 2 April 1948

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(See inside back cover)

The PROGRESSIVE FISH-CULTURIST

News and Views from many Sources on Practical Hatchery Problems

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FERTILIZATION OF A RECREATIONAL LAKE TO CONTROL SUBMERGED PLANTS

EFFECTS OF FERTILIZATION PROGRAM UPON BATHING, BOATING, FISHING

Eugene W. Surber
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CLEAN WATER is a very valuable asset, particularly in the areas close to large cities. Nature has a very unfortunate way, however, of filling in shallow ponds and lakes with heavy growths of plants. The weed beds occupy the living space for fish, interfere with swimming and boating, and cause considerable economic loss to people in the recreational business. The problem of weed growths in recreational lakes is particularly acute in the State of New Jersey. The following article shows how submerged weeds were controlled in a New Jersey lake by fertilizing the water. This idea, which was developed in connection with the management of fish ponds, appears to be very successful for larger bodies of water.

Deer Lake near Boonton, New Jersey, is an artificial lake of about 44 acres in area. It is approximately 0.5 mile in length and 0.2 mile in width. The maximum depth of water in the lake is approximately 22 feet, but most of the lake is less than 10 feet deep. The water is soft and slightly acid. The Deer Lake Club, which operates the lake, now has a limited membership of 500 families. About the shore of the lake are located a splendid clubhouse, a well-kept bathing beach, two docks for boats, and picnic grounds and trails. Quite a few of the members own canoes and rowboats which are kept on racks at the lake, and there are also several small sailboats. By the fall of 1945, the use of these had become difficult because of the large mass of submerged aquatic vegetation which had developed in the lake over a period of many years. Fishing in the lake had declined recently, probably owing to the great abundance of submerged aquatic plants.

In August 1945, the Chairman of the Fish and Game Committee requested the author of this article to visit the lake. Conditions in the lake can best be summarized by a quotation from a letter dated September 5, 1945, to Mr. R. P. Sanborn of the Deer Lake Club:

"On the visit Friday [August 31, 1945], weeds were found over most of the lake bottom. In the deeper waters, the coontail, Ceratophyllum demersum, seemed to be the predominating plant, while Potamogeton spirilus, Najas flexilis, an unidentified small-leafed Potamogeton, and an occasional bed of Anacharis were present almost everywhere in the shallower waters. The small-leafed pond weeds (species of Potamogeton) predominated, and these were in full fruit at the time of our visit. These weeds are now so abundant that trolling for fish and bait

casting are practically impossible. The large mass of vegetation decreases the capacity of the lake to produce fish, as I have already explained to you. This vegetation can be eliminated by fertilization of the water, if you can follow out the schedule outlined below. ... In figuring amounts of fertilizer required to carry out the program, I believe we should use 40 acres as the area [figure 1], since the burr-reed, Sparganium americanum, the emergent weed which grows along the shore [figure 2], has probably eliminated at least 4 acres of open water."

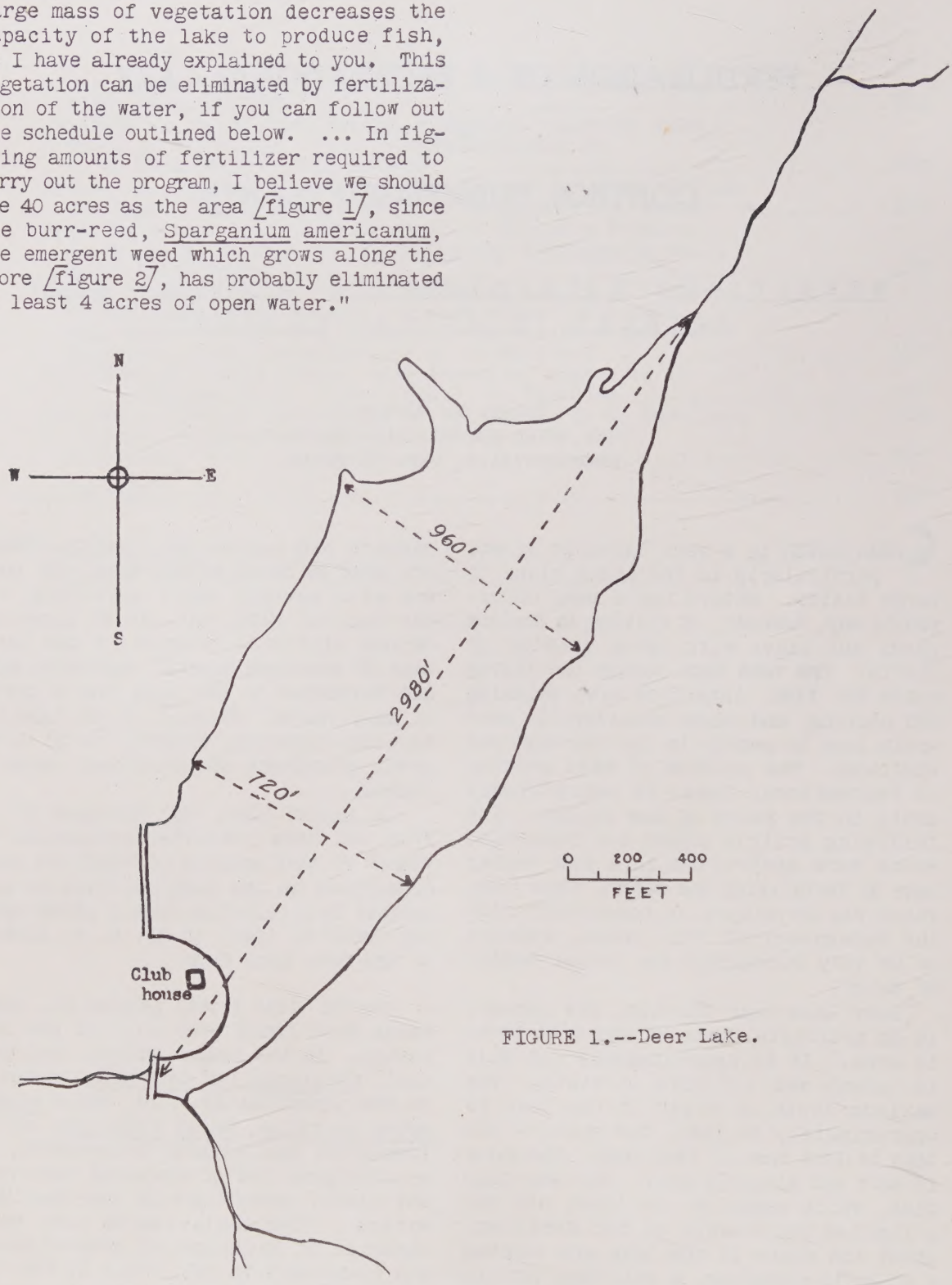

FIGURE 1.--Deer Lake.

FIGURE 2.--Marginal border of burr reeds on eastern shore of Deer Lake.

Bathing was one of the most popular forms of recreation at the lake, and the effects of fertilization of the water were considered with apprehension. Club members were informed that the fertilization program would undoubtedly cause the water to become green or dark brown from the growth of microscopic plants. Special emphasis was placed upon the fact that these microscopic plants were living, growing, harmless organisms.

The following facts bear testimony to the success of the fertilization program recommended for Deer Lake. They also furnish evidence that bathing and a fertilization program can be compatible.

On February 5, 1947, the author received from Mr. Addis E. Kocher of the Deer Lake Club a letter reviewing the work of the past year. The Club had had difficulty in locating the raw fertilizer materials recommended in the author's letter of September 5, 1945. Ready-mixed 5-10-5 inorganic fertilizer was available, however, and the original program was adhered to very closely with regard to dates of applications. Mr. Kocher's letter of February 5, 1947, summarized the schedule, presenting the data shown in the accompanying table.

The author visited Deer Lake only twice during the first year of this program. The first visit was made on June 18, and observations on the lake were reported on July 2 to Mr. A. R. Kahlenburg of the Deer Lake Club, as follows:

"Upon my recent trip to Deer Lake [June 18], I collected a sample of the lake water which was centrifuged upon my return here to determine what water-bloom forms of algae might be present in the water of the lake. The samples contained a great variety of micro-organisms, but the forms which constituted the bulk of the phytoplankton consisted of two species--Eudorina and Anabaena. Eudorina is a green flagellate and Anabaena is a blue-green alga. Eudorina could be seen with the naked eye and was, no doubt, responsible for the increased turbidity of the lake.

SCHEDULE FOLLOWED IN SPRING AND SUMMER OF 1946*

Date of application	Place	Material	Remarks
March 16	Upper Stream Inlet	2,000 lb. 5-10-5 250 lb. lime	Put in 1 week after "ice-out."
April 13	Upper Stream Inlet	2,000 lb. 5-10-5 250 lb. lime	Bloom lasted approx. one week.
May 11	Dead Areas Upper End	2,000 lb. 5-10-5 250 lb. lime	Bloom washed out in one week - heavy rains.
June 8	Dead Areas Upper Third of Lake	4,000 lb. 5-10-5 400 lb. lime	Good Bloom.
June 15	Dead Areas Upper Third of Lake	2,000 lb. 5-10-5 250 lb. lime	Good Bloom.
June 21	Dead Areas Upper Half of Lake	1,500 lb. 5-10-5 No lime	Application cut because of lack of material.
June 28	Dead Areas Upper Half of Lake	2,500 lb. 5-10-5 250 lb. lime	Bloom lasted two to three weeks.
July 20	-	-	Large volume of Potamogeton rose to top of water and was removed.

*From Mr. Kocher's letter of February 5, 1947.

"Although the turbidity of the water in the lake had increased considerably over my previous visit, the water still was not turbid enough to eliminate plants in water within the six-foot zone. In the sections of the lake where largest quantities of fertilizers had been applied there were considerable growths of filamentous algae which draped over the vegetation. The late midsummer decay of these algae will contribute much toward the development of the water-bloom forms later in the season.

"I examined the creek flowing into the lake with Mr. Parker [Superintendent] and the inflow was still of considerable volume, estimated at approximately 800 to 1,000 gallons per minute. In spite of this large inflow, water-bloom forms were developing in the lake at the time of our visit on June 18.

"I would like to hear from you regarding the present condition of the lake. I told Mr. Parker that the fertilizer should be broadcast in the future over most of the lake area."

The author visited Deer Lake a second time on August 9, 1946. At this time, large masses of Anacharis were floating at the surface, particularly in the upper end of the lake, where it was abundant. Fertilization had evidently caused the plant shoots to rot at their bases, and this permitted the masses of weeds to float up. The Anacharis at the surface was fresh in appearance, but the stems had many adventitious roots. Mr. Parker, the Superintendent of Deer Lake Club, reported that large masses of the vegetation were being drifted by the wind to the beach at the southwest end of the

lake. Here, to reduce odors, it was removed from the beach area with forks. Coontail, which occupied the central portion of the lake, was undergoing a rather rapid decomposition. Detached leaves of this plant could be seen drifting almost anywhere in the lake. The decomposition of the plant material created a high oxygen demand, as indicated by the large numbers of small sunfish at the surface in the shallower water. The first season of fertilization succeeded in removing a great bulk of the submerged plants.

During the 1946 season on Deer Lake, the program had cost $279, amounting to $7 per acre.

Members of Shongum Lake Club and of Dixon's Pond (also in the Boonton area), after witnessing the success of the program on Deer Lake, instituted similar programs on their ponds during the 1947 season. The elimination of parrotfeather, Cabomba caroliniana, from Shongum Lake by the same schedule in 1947 was of particular interest.

It was recommended to the Deer Lake Club that during the 1947 season they reduce by one-half the amount of fertilizer added to the lake, and use the same schedule. Fertilization, therefore, was at the rate of 1,000 pounds per application or 25 pounds per acre. The ice went out of the lake about April 10, and the fertilization program for 1947 was started on April 22. Succeeding applications were made on May 17, June 18, June 27, July 12, July 20, and July 26. A water bloom was reported to have formed earlier during the 1947 season than during the 1946 season. The total cost of the 1947 fertilization program was $148.70. The program virtually eliminated the coarse submerged weeds.

The author revisited Deer Lake on October 24, 1947, to find only a few scattered shoots of Anacharis and Ceratophyllum through the shallow water areas in the upper end of the lake. The beach area of the lake had been doubled in size, an indication that bathing was very much on the increase (figure 3). Two new boat

FIGURE 3.--This beach was extended in 1947 to include the entire point shown on the right.

docks had been built, one for canoes and one for rowboats. In addition, a boardwalk had been built across the narrow neck at the outlet, connecting the clubhouse area with the eastern shore of the lake. It was obvious that boating had increased remarkably since the author's last visit during the fall of 1946. Fishing also had been much better in the lake. The membership had been increased from 400 to 500 in 1947.

The most interesting feature of the program was the fact that the fertilization was successful in spite of relatively large inflows from the two creeks entering the lake. The larger stream entering at the northeast corner of the lake wa once a trout stream. It is possible th the cooler water, after entering the lak passes along at the bottom and reache the outlet without greatly influenci the water in the lake. When the auth visited the lake on June 18, there we probably in the neighborhood of 4,0(gallons of water leaving the lake at t spillway. Even on August 9, the infl from the principal creek amounted to abo 800 to 1,000 gallons per minute.

It was demonstrated in this lake th a program of weed elimination with wat blooms could be conducted without inte fering with recreational uses of the lak

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GLOBE-TROTTING

Since publication of the PROGRESSIVE FISH-CULTURIST was resumed in January 1947, its mailing list has been enlarged by requests from all over the world. The periodical is sent only upon request.

Alaska appears first in the files of addresses outside the United States proper. Eight of the Canadian Provinces are represented on the mailing list, and Newfoundland appears several times. Moving south of the border, the PROGRESSIVE FISH-CULTURIST goes to Mexico, Guatemala, and Panama. Two copies of each issue go to addresses in Cuba, and another goes to Porto Rico. South American readers are located in Brazil, Peru, Bolivia, Uruguay, and Argentina. In the British Isles, the majority of the recipients of this periodical are in England, but one copy is directed to Scotland and another to Eire. Across the English Channel, citizens of Norway and Sweden, France, Belgium, Austria, and Italy have indicated an interest in the publication dealing with fish-cultural activities in the United States. Fishery resources on the great Dark Continent are receiving increased attention, and the PROGRESSIVE FISH-CULTURIST goes to a number of points in the Union of South Africa. Requests for this periodical have come from fish-cultural centers in Palestine and India, as well as from China and the Philippines. The lands "down under" are likewise included on this mailing list, as men from both Australia and New Zealand have expressed the desire to receive this publication. The circuit of the globe is completed with several addresses in Honolulu.

GRAPHICAL METHOD FOR PRESENTING DATA ON THE GROWTH OF TROUT

David C. Haskell
State Fish Hatchery
Rome, New York

THE VALUE of studies of the growth of trout depends, in part, on the development of a suitable means of analyzing and presenting the data. In the following paragraphs is presented a new graphical method which seems to the writer to be more successful than those previously used.

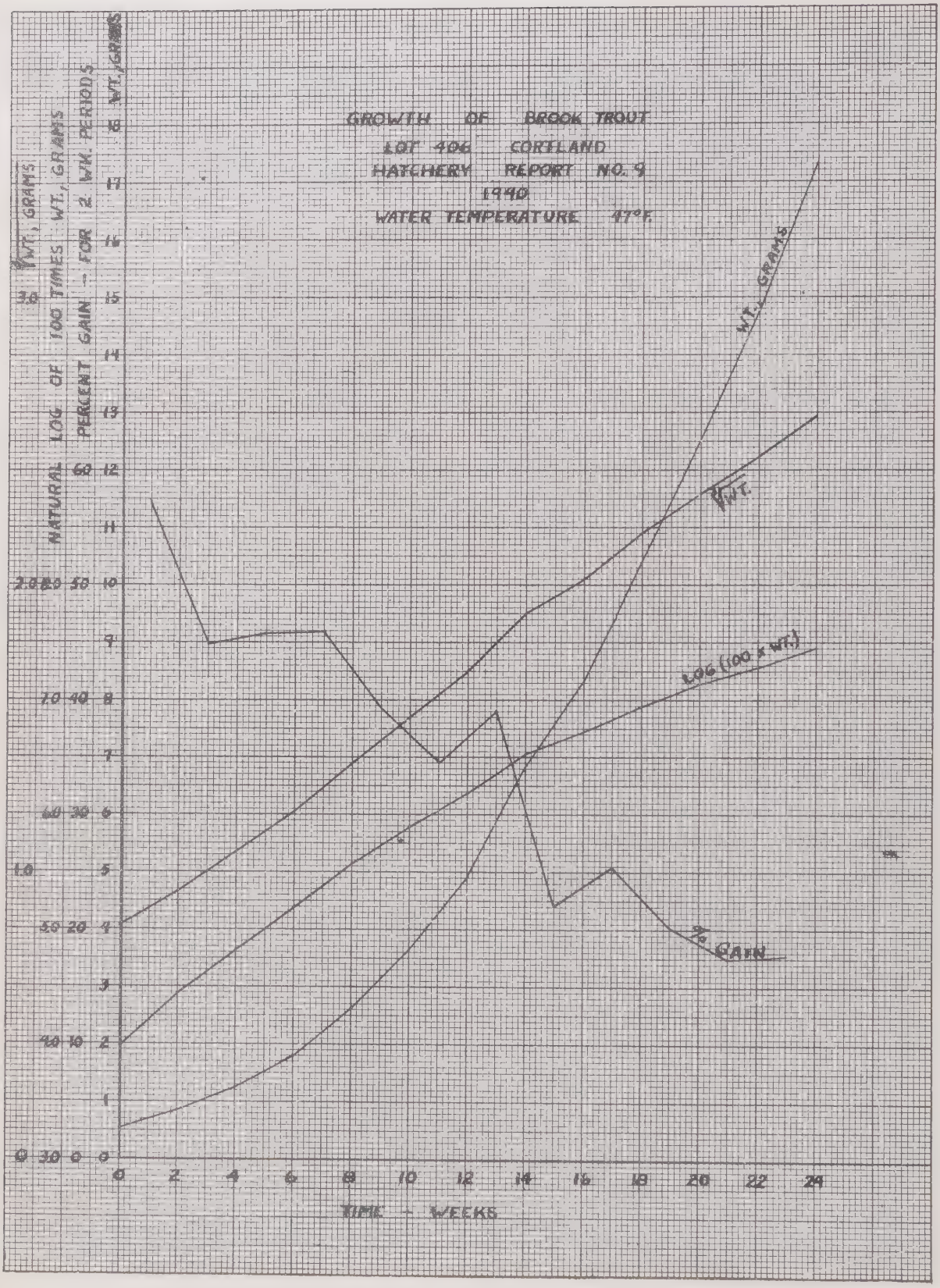
In presenting data for comparison, as data pertaining to two lots of trout, it is desirable that the resulting graph be a straight line: it is easier to draw a straight line through a group of points than to fit a curve; also, straight lines are easier to compare than curves. For these reasons it is customary in growth studies to search for a measure of growth which will produce a straight line under conditions of normal growth.

For trout, various methods used in studies of plants and animals have been used with varying degrees of success. Some of these methods are illustrated on the accompanying graph, which shows data from Phillips (1940). For the present purposes, it will be assumed that the growth of trout is being considered under conditions of constant water temperature and "normal" hatchery conditions including adequate feeding of a suitable diet. Under these conditions if the average weight of the fish is plotted against age or time, the resulting curve rises very rapidly, and is not suitable for reporting results because a scale which will include the growth over a period of even a few months compresses the data for the first few weeks so much that differences usually cannot be observed.

The logarithm of the average weight is frequently plotted against age by use of semilogarithmic graph paper, and for short periods this procedure appears to produce linear relations. In any extended study it is found that there is a gradual curvature downward from a straight line, impairing the value of the graph. The use of logarithms is based on the theory of autocatalytic growth, in which the rate of increase of weight at any time is proportional to the weight. For autocatalytic growth, if the percent gain were calculated for very short periods, as daily, the percent gain would remain the same as the animal grew. For trout the percent gain is known to decrease as the trout increases in size. Various attempts have been made to show growth by the plotting of percent gain. For the reason just explained, this system is not entirely satisfactory.

The writer has studied various other methods of plotting growth, and the method to be presented appears very promising. It has been found that if the cube root of the average weight is plotted against age or time, a straight line will fix the plotted points over very considerable periods. In fact, a plot made of data (Tunison, 1938) on brook trout for their entire life span, was found to approximate a straight line until the last year, when growth gradually stopped.

The cube root of the weight also opens possibilities for the statistician: if


GROWTH OF BROOK TROUT
LOT 406 CORTLAND
HATCHERY REPORT NO. 9
1940
WATER TEMPERATURE 47°F.
WT., GRAMS
NATURAL LOG OF 100 TIMES WT., GRAMS
PERCENT GAIN - FOR 2 WK. PERIODS
WT., GRAMS
WT.
LOG (100 x WT.)
% GAIN
TIME - WEEKS
0 2 4 6 8 10 12 14 16 18 20 22 24

the growth is represented by a straight line in this method, then for equal periods the increase in the cube root of the weight will be equal. Data, therefore, may be treated by the methods of linear regressions (Snedecor, 1940).

The straight line produced by plotting the cube root of the weight maintains under conditions of constant temperature. A limited study indicates a good possibility that for a given set of conditions the slope of the straight line will depend on the temperature in a manner which may be determined by analysis. Also, in an experiment with varying temperature there is some reason to expect that the growth will be a series of connected straight lines, the slope of each dependent on the temperature at the time.

Since the cube root of the weight plotted against age makes a straight line, it at first appears that if weight were plotted on log-log graph paper, the result would be a straight line with a slope of one-third--because it is characteristic of such paper that the slopes of straight lines on it are equal to the power of the dependent variable in the equation for the function being plotted. Unfortunately, a straight line is obtained only when the function being plotted passes through the origin, which for trout would mean zero weight at zero time, a condition which would not obtain in an experiment, or, in fact, a condition that probably could never be met because the trout has a definite weight at the start of feeding.

In conclusion, tne writer would be grateful for correspondence from workers who may try the cube-root method in their own studies.

Acknowledgment

The writer wishes to acknowledge the help of Mr. A. V. Tunison, Assistant Chief, Division of Game-fish and Hatcheries, Fish and Wildlife Service. Mr. Tunison furnished a quantity of unpublished growth data for study, in addition to the published data listed with this paper.

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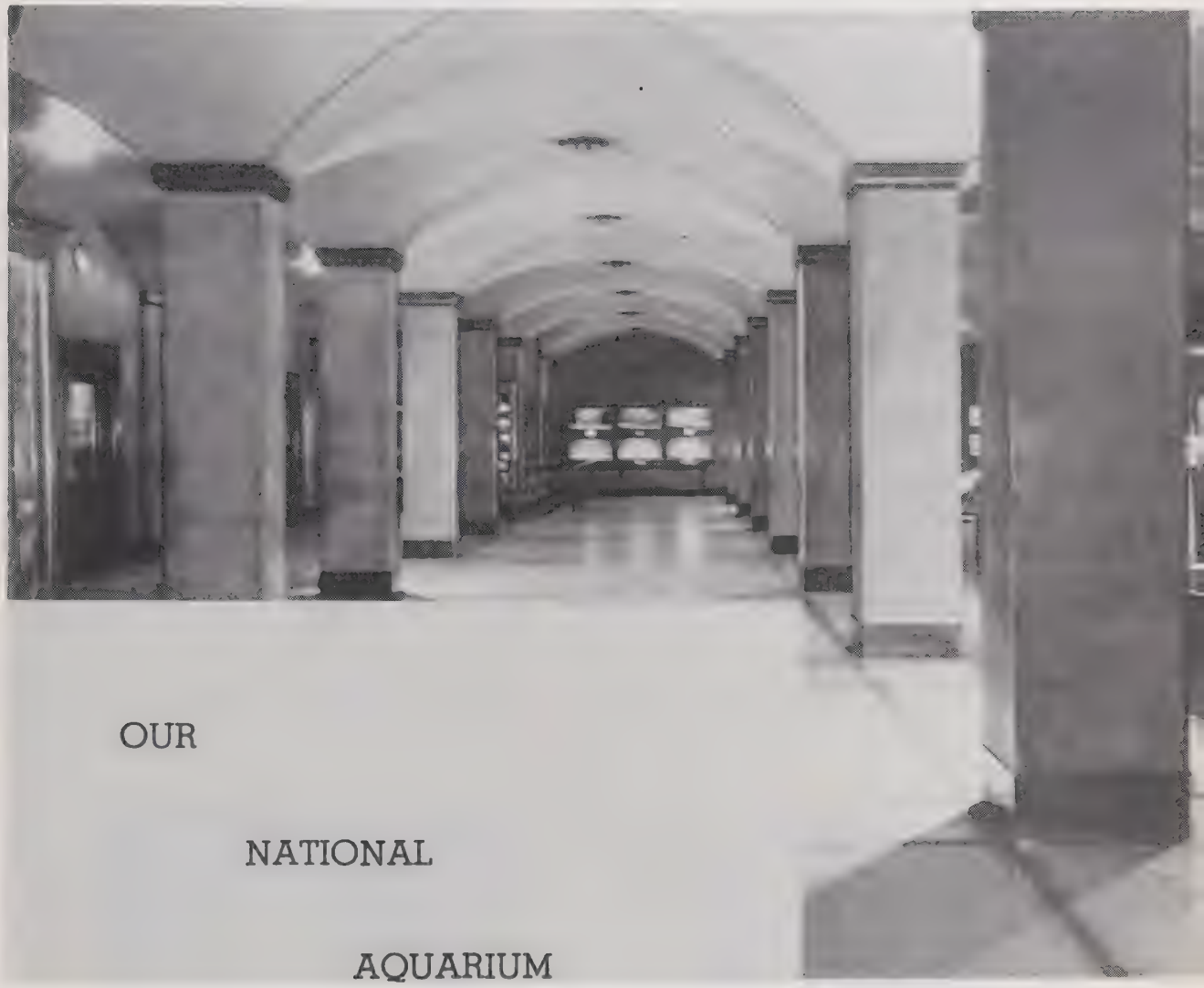
MALLARDS AND BREAM

At the U. S. Fish-Cultural Station at Marion, Alabama, 150,000 fingerling and 312 adult bream were lost late in December when their 3-acre pond (which had been lowered for removal of the fingerlings) was invaded by a large flock of mallards.

DIAMOND BACK
TERRAPIN



OUR NATIONAL AQUARIUM

John C. Pearson
U. S. Fish and Wildlife Service
Washington, D. C.

THE WASHINGTON Aquarium, the oldest public aquarium within the United States, will celebrate its sixtieth birthday during 1948. Established in 1888 by the former U. S. Fish Commission, the Aquarium has been under the direction of the Fish and Wildlife Service since 1940, when that agency was created by the consolidation of the Bureau of Fisheries and the Bureau of Biological Survey. The Aquarium is now situated under the main lobby in the Department of Commerce Building on 14th Street between E Street and Constitution Avenue.

The National Aquarium seeks primarily to maintain an attractive display of the principal fresh-water game fishes which are propagated and distributed throughout interior waters of the country. An early writer stated its aim: "The Aquarium is a place of marvels for the general public and especially for the fisherman who may rarely see a fish distinctly in stream or lake and to whom the forms, colors,

and actions of game fish are as novel as if the inhabitants of the aquarium were made especially for exhibition."

Of equal interest are the Aquarium's secondary objectives: to develop better methods of maintaining native fishes under artificial conditions of confinement, to stimulate such research in aquatic biology as can best be advanced by observing animals at all times in a large aquarium, and to give advice to the American public on the care of a home aquarium and the outdoor display of ornamental pond-fishes.

The ancient Romans spared no expense to make their fish-ponds as large and attractive as possible and to obtain valuable and beautiful fish for stocking them. The Orientals spent many generations in their selective breeding of ornamental goldfish. These were introduced into Europe during the 17th century, according to Pepys, who noted in his diary: "fishes kept in a glass of water, that will live forever--and finely marked they are, being foreign." Although ingenious and successful devices for holding fish alive have been in vogue for many centuries, the public aquarium--now a world-wide institution for the exhibition of aquatic life--has developed only within the past century.

About 1850 an Englishman, R. Warington, sent to the Chemical Society a letter about his experiences in keeping a fresh-water aquarium. It was a simple affair, merely a glass globe of fresh water in which two goldfishes had been placed together with plants of Vallisneria. Soon Warington introduced some pond snails to eat away the green algae which formed along the inner surface of the glass. Two years later, this investigator and another Englishman, Philip Gosse, experimented after a similar fashion with sea water. Tanks were constructed for the purpose, and marine animals and plants were introduced in such proportions as might be expected to neutralize each other's respiration.

The writings of Gosse aroused popular interest in aquatic life, especially marine. Largely owing to this interest, the first public aquarium in the modern sense of the term was opened in the Zoological Gardens at London in 1853. Soon aquariums were constructed in many European cities. The first idea of presenting to the American public a display of live food and game fishes seems to have been suggested in 1872 by Spencer F. Baird, who wrote: "I would respectfully call the attention of the commissioners /of the Centennial Exposition of 1876/ to the propriety of taking steps for establishing an aquarium as part of the exhibit at the coming Centennial. You will observe the great success of these establishments which have been erected at Berlin, Hamburg, Naples ..."

Excellent public response attended several temporary exhibitions of native fish at American expositions held after the 1876 Centennial. This response was influential in the establishment of a permanent aquarium at the Central Station in Washington in 1888 within the space available in the Fish Commission Building at 6th and B Streets. This first public aquarium in the National Capital was fitted out with a "Marine Grotto," which contained 24 tanks of salt-water fishes as well as 25 tanks of fresh-water species. Its success was partly responsible for the establishment in 1893 of the famous aquarium at the Battery in New York City.

For nearly 50 years, the Washington Aquarium was maintained in the official headquarters of the Fish Commission and later of the Bureau of Fisheries. Eventually this aquarium occupied about 5,700 square feet in the main building and about 2,100 square feet in an annex. There were 27 tanks, which held from 70 to 700 gallons of water each, and a floor pool of 13,000 gallons. As time went on, the displays were arranged to present only fresh-water fishes and other aquatic life of interior waters. Notwithstanding the limitations in space, funds, and personnel, this aquarium served well to show the local public (and the many visitors to Washington) the principal game fish reared and distributed by Federal and State Governments in their efforts to prevent depletion of a valued natural resource.

In 1932, when construction was begun on the new building of the Department of Commerce (which included the Bureau of Fisheries at that time), there arose

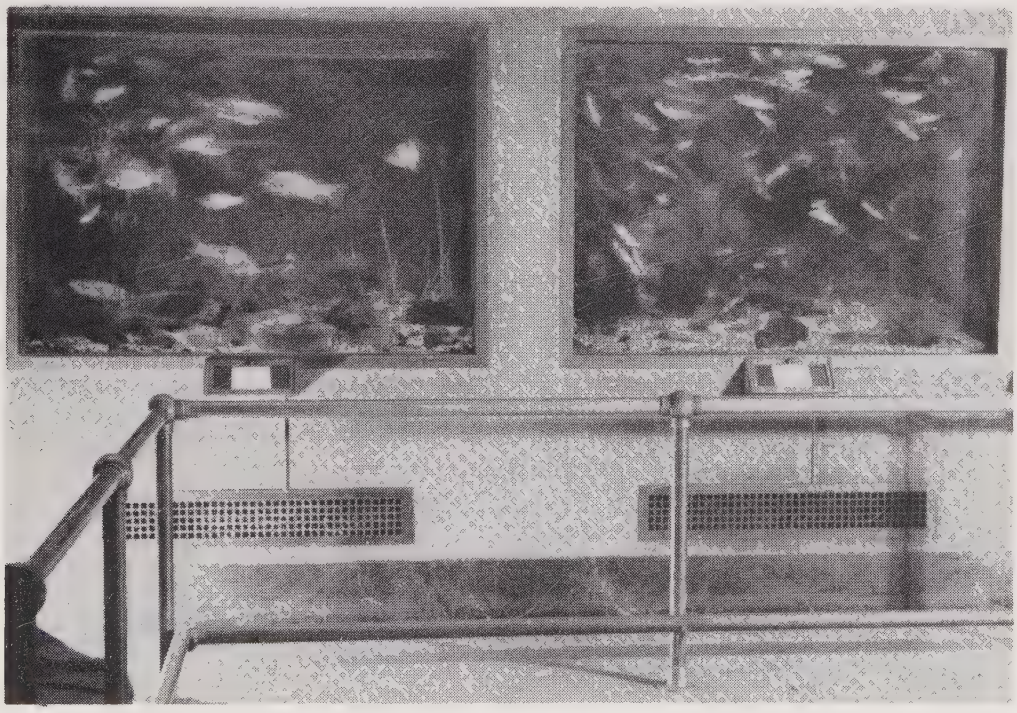
an excellent opportunity to build a more modern aquarium in Washington. In the basement floor of this immense office building the present Aquarium came to occupy a space 148 feet long and 48 feet wide.

The Aquarium has 47 exhibition tanks: 3 of these have a capacity of 2,000 gallons; 20, of 1,000 gallons; and 24, of 50 gallons. Three small floor pools and some large display cases complete the exhibition facilities. Within this space (quite limited in comparison with that of public aquariums in San Francisco, Chicago, and several other cities), the Fish and Wildlife Service is able to present a selected collection of the principal fresh-water game fishes of the country, as well as collections of miscellaneous native fishes, tropical toy fishes, and the larger aquatic reptiles and amphibians.

Happily, the problems which beset the management of a public aquarium remain unknown to the general public. In its effort to maintain live fish, the Washington Aquarium gets off to a poor start by receiving each day many thousands of gallons of chlorinated city water to supply its 100 tons of tank water. Before it can be admitted to the tanks, this city water (made healthy for human beings but rendered deadly to aquatic life) must be passed through carbon filters to remove the chlorine.

Again, the hot Washington summer requires complete refrigeration of the water supplied to the tanks of northern fishes. The temperature of this water should not exceed 60° F.

Fishes show variations in temperament, requiring patience and consideration from aquarium keepers. Our muskellunge or great pike will readily seize dead fish and swallow them whole, but he will reject in disgust the same variety of fish served to him as a fillet. The Amazonian beauty, the discus, finds pleasure only in consuming enchytraeids, small white worms reared on a diet of bread and cream. Like humans, however, fish can become adapted to many new circumstances; so the inhabitants of the Aquarium learn to enjoy the normal bill-of-fare of chopped heart of horse each Monday and fillet of sea trout every Thursday. Pampered pets, such as the baby gar from Vermont or the jewelfish from North Africa, are given special live foods, as Gambusia, the mosquito-destroyer. All guests are given an occasional holiday treat of black goldfish.



Reactions of aquarium spectators are watched as carefully as the behavior of the fishes themselves. It has been found (but not by Gallup Poll) that women adore the fancy Oriental goldfish--the gorgeous Veiltails, the velvety black Chinese Moors, and the multi-colored Shubunkins. Virile men quite naturally prefer the rainbow and brook trout, although some strong, silent individual may be fascinated by the austere musky. Most children are fascinated by aquarium oddities, like Super-Diamond, the two-headed baby terrapin from North Carolina. The children especially enjoy the sight of Super-Diamond eating heartily with both mouths at the same time. For all ages and sexes, however, the best attraction is the shallow pool filled with turtles of all varieties. Truly, fishes do belong to another world--the Aquatic World--but turtles, especially baby turtles, exist in a world everybody knows and generally likes.

Good as well as bad traits show up among the visitors at any public aquarium or zoological park. Kind-hearted persons always inform caretakers when Iky, the black bass, takes a bite of a comrade or when Winky, a mean South African turtle, snaps some flesh from the leg of a companion of many years. Any disorders among the inmates of the Aquarium are promptly perceived and reported by the most observant public. Fortunately, neither bread nor peanuts can be thrown to the fishes, but the floor pools collect their share of small coins thrown at the alligator to make it bestir itself.

Ambitious parents who want to take a baby terrapin or a fancy goldfish back home for the children occasionally offer bribes to the attendants. A "gem collector" once offered $5 for a pearl-bearing oyster from Hawaii. A good motto for any aquarium management is: If it fits into a pocket, keep it locked up.

Patronage at the Washington Aquarium fluctuates according to the time of day, week, and year. Saturday and Sunday afternoons, especially in spring, are favorite times to visit the Aquarium. Open daily throughout the year from 9 a.m. to 5 p.m., and easily accessible from downtown Washington and many large hotels, the Aquarium attracts the public at all times.

Future improvements to the Aquarium call for better lighting effects in the display tanks (lighted by electricity), more naturalistic backgrounds for the exhibits, and a more complete display of native food and game fishes so well appreciated by many millions of American fishermen. The Aquarium must depend for its exhibits, not only upon the Federal fish hatcheries, but also upon gifts from private organizations and individuals. If you have or know of any unusual (size, shape, or color) fish, turtle, or similar aquatic life which can be delivered safely to The Aquarium, Commerce Building, Washington, D. C., the Director will gladly furnish shipping instructions.

No matter how conservative the count, it is usually impossible to convince the fisherman that there are that many bass in his pond.

FACT AND FICTION IN SPAWNTAKING

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and

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BEFORE APOLOGIZING for the title, let me describe the conditions that were responsible for the experimental program herein outlined. For those who are unfamiliar with the fish-cultural station of the Fish and Wildlife Service at Yellowstone National Park, it will be interesting to learn just how the spawntaking program is conducted. Briefly, there is a rush into the Park the day the roads are cleared of snow, a mad scramble to take around twenty-five million blackspot eggs, and a race to close down before the first flakes begin to fly in September. Under a cooperative arrangement, the various western States send a man from their fishery departments to assist in the work.

With a crew thus selected, each year sees new faces at the hatchery and--most important--new and sometimes startling variations in spawntaking techniques. There are times when these variations produce eggs of such high quality that quotation of the actual percentages in eyed eggs would likely produce a smile and the surmise that mathematics had more to do with the results than the spawntaker. However, the opposite is too often true: little need be said to bring home the seriousness of a 15-percent loss on one spawntaker's work, especially if he is responsible for four or five million eggs. When you consider how the spawntaking process developed, you have small wonder that there are so many different methods. Should wrong methods be introduced, they may be handed on from man to man until they are practically accepted as standard procedure.

The problem of determining just what factors were responsible for egg losses made up the body of our experimental work. Now, you may be inclined to scoff at this as constituting any problem. Perhaps you'll argue that any experienced man can watch a spawntaker for a very short time and immediately put his finger on the trouble; if so, then you believe exactly as we once did. This is the way it actually works: Spawntaker No. 1 goes out to observe the source of bad eggs, and his criticism is, "Too much water in the spawning pan." The word goes out, but the eggs still come in bad. Spawntaker No. 2 goes out to observe, and the report comes, "He isn't bucking enough." And thus it goes. From every observer a different report appears. The trouble may be laid to everything from broken eggs to green fish; and if a lucky guess is made, the eggs may improve; but chances are that the poor spawntaker in question

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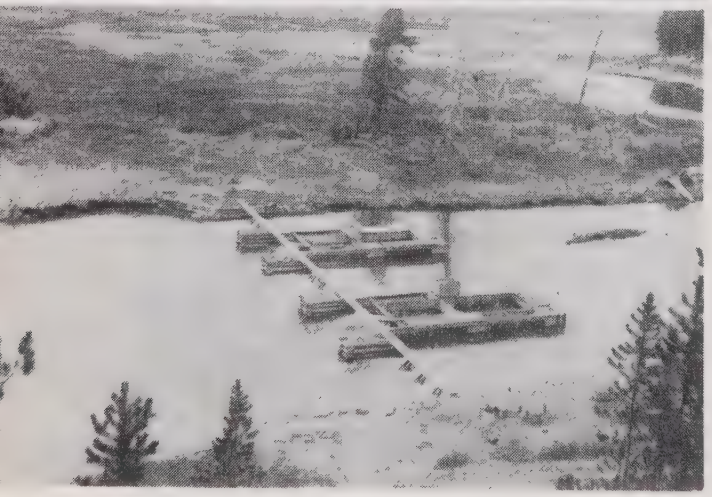
See also:

Keil, W. M.
1936. Spawntaking operations. Prog. Fish-Cult. 22: 1-6.

Silliman, R. P.
1936. An egg-handling experiment. Prog. Fish-Cult. 22: 15-17.



(Photographs courtesy of the authors)

Clear Creek trap with a common visitor.

Washing eggs, a time-consuming job.

The Pelican Creek trap.

will become so confused at the avalanche of conflicting advice that his results are worse and worse. Most important, if the eggs do improve, nobody knows why.

At one of our substations we subjected some eggs to every type of abuse in the book and treated other samples with all the care you'd show a new-born baby. The tests were carefully run according to a prearranged plan which was the result of many a spirited bull-session around the bunkhouse fire. If a spawntaker insisted that he got better results by first adding half an inch of water to his spawning pan, we included this bit of information in our tests. On the other hand, if a man mentioned that he always dumped bloody eggs into the creek, we also tested the practicality of such action. We ended with a schedule which included some ninety different tests and involved around three hundred thousand eggs.

At the end of the summer, when the work was completed, we sat back, looked at what the figures said, and looked again. We found that practices we had adhered to religiously for 20 years apparently had no foundation whatsoever, and that is why we called this article "Fact and Fiction in Spawntaking."

The high points are listed briefly. It should be explained that we consider some of the results open to question and assuredly feel that a great deal more work is needed on all of them.

Water-Hardening of Eggs

This was perhaps one of the most startling results--so much so, in fact, that we considered it alone as sufficient return for the entire program.

It has long been the practice of fish-culturists in the West to allow a keg of eggs to remain absolutely motionless for 45 minutes to an hour after the last pan has been emptied into the keg. It was thought that the eggs were extremely sensitive during this period and remained so until the "water-hardening" process was completed.

In testing this theory we took six sample lots, each consisting of the eggs from three females, and washed them at intervals ranging from 10 to 60 minutes

after fertilization. The results were exactly contrary to what we expected. The sample washed at 10 minutes had a loss of only 3.1 percent. As the interval increased, so did the loss until at 60 minutes it stood at 7 percent, or more than twice as much.

We were inclined to view this result with a critical eye; but if true, it meant a very substantial saving in time. Consequently, we decided to try the procedure on a full keg or approximately 150,000 eggs. The eggs were taken and washed immediately upon completion of stripping: the result--only 2.5 percent loss. Since that time more than 5 million eggs have been treated in a like manner, and no increased loss has been detected. When eggs are washed in this manner, "sticking" is often apparent but seems to have no ill effect on final eyeing-up percentages.

Male-Female Ratio

Here, too, we received some surprising answers. The tests were run on five different samples, starting with one male to one female and increasing to one male to nine females. At the 1 to 7 ratio the loss was only 2.3 percent. The loss for the 1 to 9 ratio was considerably higher, but other factors were probably responsible.

These results correlated closely with the results of a spawntaker who always took five females to a pan before using a male. If the fish were running ripe, he increased the number to 10 and more before adding the milt. His final eyeing-up percentage for more than three million eggs was 96.12.

One thing assuredly is important, however, if the ratio of males to females is very low: the eggs must be taken with extreme rapidity and kept very dry.

Effect of Water in the Spawning Pan and Life Expectancy of the Sperm and Egg

Although the "dry" method is very widely used in the taking of eggs, it is surprising how many spawntakers still insist on putting half an inch of water in the pan before stripping begins. We hoped to demonstrate the fallacy of this practice, and for once our results were as we expected.

We compared the length of time the sperm retained its potency when dry with the length of time it retained its potency in half an inch of water. The egg was timed similarly to determine how long it could be fertilized, both dry and wet. The two were timed, from immediate removal from the fish to 5 minutes before fertilization was attempted. The tests were made separately, of course. The series was run absolutely dry, first, and then was repeated with half an inch of water in the pan. Fresh eggs were added to timed sperm, and fresh sperm was added to the timed eggs. The results left no doubt that, if time was a factor, the dry method was far superior. When dry, the eggs taken with the timed sperm had a loss of only 0.4 percent at the end of 5 minutes, and the timed eggs had a loss of only 2.1 percent for the same time. When wet, however, the loss for the timed sperm was 100 percent after 1 minute, and for the eggs was 100 percent at the end of 2 minutes. Remember, this "wet" means only ½ inch of water!

In running a so-called "experiment," it is not overly difficult to prove all sorts of things that look very convincing on paper. It didn't take long, however, for one of our spawntakers to spot the weakness in the foregoing tests. When he reviewed the results, his objection was natural. He readily conceded that the sperm might be effective for a much shorter time but argued that fresh milt could be added with every female and the results would be no lower regardless of the water present.

Back to the creek we went. This time five tests were run, differing only in the amount of water added to the pan (totally dry to 3 inches of water) before stripping began. The eggs from three females were taken for each test. In this series fresh sperm was always present. When final results were in, everyone was convinced. For each half inch of water added, the loss rose more than 1 percent, from 2.1 percent for a totally dry pan to 11 percent at 3 inches.

As a dripping spawning glove is one of the best ways to introduce water to

a pan, we observed with great interest the results of a newcomer who worked with his hands bare. For weeks his percentages humbled all competition, and it is quite possible that this factor was partially responsible.

Effects of Various Impurities

Conditions on a station such as this often are responsible for the presence of numerous impurities in the spawning pan. The use of outboard motors in going from one stream to another often results in the presence of gas and oil with the eggs. Likewise, a virulent population of mosquitoes encourages the introduction of various repellents to the pan. These impurities have often been blamed for unexplainable losses, and the testing of their actual effects produced some unexpected answers.

Each impurity was the object of three tests: the first involved a very minute quantity; the second, a moderate amount; and the third, an extremely excessive amount.

The results from blood, gasoline, and lubricating oil were almost identical. In no test did the loss exceed 7 percent, although the pan was at times completely saturated with the impurity. On this basis we are inclined to minimize the importance of these factors, for when eggs practically swimming in gasoline suffer so little, it is hard to believe that enough gasoline could wash from a spawntaker's hands to cause an appreciable loss. Strangely enough, however, a very minute quantity of the impurity produced a loss almost equal to that noted with an extremely excessive quantity. Now, whether the loss was the result of other factors in the first place or was caused by some unguessed relationship, is a question we haven't yet attempted to answer.

The mosquito repellent, "6-12," gave some definite results. Only three drops produced an 8.9-percent loss, and 3 cubic centimeters boosted it to 70 percent. Something for the spawntaker to think about!

Fish slime, too, was fairly conclusive, indicating that it may play its part: ½ cubic centimeter gave a 4.7-percent loss; 5 cubic centimeters, a 27.2-percent loss.

As considerable work has already been done on the effect of broken eggs, the results here achieved are not surprising. Three broken eggs produced a 6.7-percent loss; 25, a 16.4-percent loss.

General Practices

It is established procedure at the Yellowstone Station to keep a careful record of each spawntaker's work. The losses are tallied when the eggs are picked, and at the end of the season the percentage of fertilization is thus computed. The science of mathematics is rarely a factor in producing unusually good results, and we place considerable confidence in these figures as indicators of desirable spawntaking practices.

Few spawntakers will fail to argue the merit of their particular method of mixing the sperm with the egg, and many put on this phase the blame or credit, such as it may be, for their percentages. Various methods were well represented during the time that our experimental work was in progress, and it is interesting to note the percentages in relation to the complexity of this particular operation. Spawntaker No. 1 used his fingers and often the tail of a fish to effect a thorough mixture. His percentage of fertilization was 95.24 for the season. Spawntaker No. 2 added water to each pan after stripping and thoroughly mixed the contents with pan manipulations. His percentage was 96.12. Spawntaker No. 3 took little trouble of any sort to effect the mixture other than an occasional shake of the pan. His percentage was 96.78. From these results we are inclined to think that this phase of spawntaking rarely is responsible for excessive losses, on condition that the eggs are taken dry.

There are two schools of thought on the proper handling of a pan of eggs immediately after the last fish is taken. In the Park we place them, without previous washing, directly into a keg, where they remain until the keg is full. On the other hand, many stations wash each pan thoroughly, removing all milt before adding them to the keg. The only objec-

tion to the second method is the time consumed in the additional washing (which is considerable, as often one man is employed at this task alone). In washing the eggs taken by the first method, however, it is obvious that eggs in all stages of water-hardening are disturbed, especially when washing them immediately after stripping has been completed. Although we do not attribute any extra loss to this immediate washing, we are experimenting with a new method that may have possibilities. A wire mesh basket was secured in the stream with a gentle current flowing through it. As each pan was completed, it was emptied into the basket, where the eggs were washed immediately, gently, and with no loss of time, by the action of the stream. On an experimental basis, losses were less than half those of the other two methods. Though lack of time precluded further work on this phase, we are putting it on the schedule for future investigation.

Perhaps the most heated discussions on any spawntaking station deal with the "pros" and "cons" of stripping cleanly. Old-timers insist that shells and old eggs are the result of not stripping cleanly, but here in the Park we find conditions that tend to refute this belief; and although we do not advocate the practice, we see many things in favor of it.

In the first place, fish in Yellowstone Lake are of an extremely high quality; the occurrence of shells is quite exceptional on the majority of the stations. It often happens that our quota of eggs nears completion at the height of the run, and there can be no doubt that stripping is not too clean while the men secure what eggs are necessary to finish. This practice has never produced ill effects during the succeeding seasons, however, and we doubt that it ever would.

The primary advantage in not stripping cleanly lies in the raised percentage of fertilization of those eggs actually taken. This has been shown repeatedly, so often, in fact, that a high percentage is frequently taken as an indication that the spawntaker is following the practice. The reasons for this are obvious to those who have taken spawn, for it is in extracting the last hundred eggs that one

A temporary trap at Columbine Creek.

Interior of the Cub Creek trap.

Hatchery boats at Peale Island Station.

Clear Creek trap, snow in background.

is most apt to break shells and to force from the fish eggs which may not have fully matured. An additional factor is the danger of injury to the fish, which may most easily be harmed at this time. We feel that additional work may well show that leaving the last hundred eggs in a fish will pay dividends in the long run, for the best eggs taken during the 1947 season were taken in this manner. The test was run on 180,000 eggs. The entire series had the eyebrow-raising percentage of 98.5.

Suggestion

In closing, it is our very earnest desire to put across the most important part of this article. It has not been written to show how much we know, but rather how little we know. Doubtless, many of you have exclaimed while reading this: "Hell's bells! I already knew that." And that is exactly what we want to know--just how you are handling the various phases of egg-taking on your stations, what variations you have found to be of value, what kinks make the process easier, and what you don't believe is worth a continental damn. Pass around the results of your own experience. Jot down a line or two and send it to the authors.[1] We'll see that it goes the rounds. Let's eliminate about 90 percent of our egg-picking.

Acknowledgments

Thanks are extended to Dr. Ivan Pratt, Dr. Kenneth L. Gordon, and Dr. F. F. McKenzie of Oregon State College for invaluable assistance through contributions of both suggestions and materials for use in the project. Dr. Roland K. Meyer, University of Wisconsin, generously supplied a quantity of carp pituitary extract for experiments which are not described pending collection of more quantitative data. Special thanks go to all members of the 1947 crew for their cooperation and support.

[1] As these experiences would be of interest to all, it is suggested that such information be forwarded also to the Progressive Fish-Culturist.--EDITORS.

USE OF THE BLOCK SYSTEM IN FISH-CULTURAL OPERATIONS

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THE WORKING of the block system, and the reasons for its inauguration, may be better explained by first describing the background of fish-cultural operations at the Coleman Station.

The Coleman Station is a part of the Central Valley Project and artificially propagates the Chinook Salmon. This station has steadily increased its production since the beginning of operations in 1943. Most of the resulting fingerlings of the annual egg collections are released in the spring of each year after a short feeding period. The remainder are reared through a period extending from April to October. The numbers held for the summer rearing program have increased annually. The table shows this increase in production of summer-reared fish.

Production of Summer-Reared Fish

Year	Number released	Pounds released
1944	177,225	8,233
1945	432,137	15,748
1946	918,309	41,451
1947	1,165,534	71,075

The block system was not used until 1947. In 1947 it was found that, despite a much smaller number of man hours per 1,000 pounds of fish produced, greater success was achieved with this system than in former years with other methods. The use of improved fish-cultural techniques contributed a great deal to this saving, but the block system also assisted to a large extent.

The production operations prior to the 1946-47 season were conducted on a mass-production or assembly-line basis. Under this system, personnel were assigned to prepare fish food, others to feed the fingerlings, and still others to the general care of the stock. The assignments of personnel to these several tasks were subject to continual changes. Fish-culturists performed certain duties for a day and other duties the following day. This procedure was fairly satisfactory during the first years of operation, but as production increased, faults began to appear. The fish did not receive proper attention at all times because the men did not have any specific responsibility in the general care of the stock. There was no personal interest in whether the work assignments were for the general welfare of the stock or just "to get the work done." Some of the personnel became specialists in some phases of the operation but at the same time had little knowledge of the procedures followed in other phases. Conflict in work and

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During 1947, a total of 25,794,652 salmon, weighing 109,779 pounds, were planted from the Coleman Station. These fish consumed a total of 282,644 pounds of food, which cost $18,099.75. As far as we know, this is the largest producing salmon hatchery in the world. If any of our readers have information to the contrary, we shall be glad to receive the facts.--EDITORS.

assignments caused some part of the stock to receive proper care while other parts were more or less neglected. One group of personnel might endeavor to feed ponds at the same time at which another group was trying to clean them. This confusion caused a slowing-down of operations. Inadequate records were kept because of improper knowledge of what reports were necessary. The responsibility for close observation of the fish at all times was poorly distributed under this system.

During the summer of 1946, these organizational break-downs had reached the point at which some other system seemed necessary to keep abreast with the increasing production. The block system was formulated and presented to the district supervisor and the hatchery superintendent. The fundamental principle of the new system was to assign a certain "block" of fish as the immediate responsibility of one man and to furnish him with any assistance he might require in the care of this block of fish. The block leader was to perform all work necessary within his block, to plan and execute the details of his work, to keep adequate records, and to observe closely the condition of the fish at all times. The whole stock was to be divided into a number of blocks such that each leader, though not overburdened, would have a large group as his responsibility.

IN PRACTICE

With the approval of the district supervisor and the hatchery superintendent, this system (after some experimentation during the balance of the 1946 production year) was organized on an operational basis and finally adopted. The system has been used during the 1947 production year and has given excellent results.

A description of the block system as it was used at the Coleman Station during the 1947 season, follows: The stock on hand (1,200,000 Chinook Salmon fingerlings) was divided into four blocks of approximately 300,000 fingerlings. Each block was under the direct care of a fish-culturist as block leader. The block leaders were given under-fish-culturists as assistants when the need arose. Usually two block leaders had one assistant who divided his time between the two blocks. Each block leader was responsible for all stock within his block. He fed the fish, recorded mortalities, cleaned the ponds, and closely observed the fish for condition and disease. If disease treatments were recommended, he gave them in the prescribed manner. In the event that a block leader was absent, the responsibility devolved upon his assistant. Another fish-culturist was put in charge of the feed room. His duties included the proper care of fish feeds, their preparation in proper quantities and amounts and at the time required by the block leaders; he was given the assistance required for the execution of his duties. The over-all production of the hatchery was thus broken into a series of small operations which could be reviewed individually and as they affected the other operations. Closer observation of the fish was effected under the block system, as the man who worked day after day with a particular group of fish under his immediate control, had a greater opportunity for a constant check of his stock.

The inefficiencies which tend to arise from the centralization of responsibility are eliminated when the block leaders have a part of the operations under their control. This has freed the superintendent and foreman from the necessity to watch many minor details. Their job now is to coordinate the work of all blocks and the feed room, to provide needed assistance, and to supervise the over-all operations. Each block leader furnishes adequate records of the fish within his own group; thus the total information is more efficiently assembled.

The training each employee now receives cannot be discounted. A fish-culturist gains experience in being responsible for a group of fish. This is excellent training for advancement to the grade of foreman. An under-fish-culturist now has the opportunity to be "on his own" for short periods when his block leader is absent. This, too, trains him for advancement to the fish-culturist grade.

Under the block system, all employees at the Coleman Station have shown increased interest in fish culture and production. Comparison of the different blocks has caused the development of a competitive sense which has assisted in bringing about more efficient operations. Morale is high because each employee feels that he is now an important "cog in the wheel" and that his efforts are contributing toward more efficient and increased production.

RECOMMENDATION

On the basis of the success at Coleman, it is believed that the use of the block system might be of considerable benefit at other stations. The system is flexible and can be adapted to the needs of the station. The fundamental idea, "Let one man care for and be responsible for one block of fish," is the only principle which need be followed. The planning and coordination can be much less difficult when block leaders are familiar with the program and when their assistance is fully utilized in the execution of the many details incorporated in a successful fish-cultural program. Even at smaller fish-cultural units this system might be used to advantage when more than one fish-culturist's services are required for production. The system would assist in training personnel for more responsible positions, and the competition that might be fostered would increase interest in operations. As the block leaders would assume the responsibility for the many details of the fish-cultural program, the superintendent would be relieved of the necessity for close supervision of the work program at all times.

The following program is suggested for the inauguration of the block system:

1. The number of fish to be reared during the year should be estimated.

2. The number of personnel required to handle these numbers effectively should be determined.

3. The number of blocks required should be determined on the basis of the number of fish to be reared and the number of personnel available.

4. There should be a system of individual block records which will give a complete picture of block production and which can be incorporated as a whole into the station production records.

5. In order that each person may have an adequate knowledge of what is to be expected, a conference of the prospective block leaders, assistants, and their supervisor, should be held prior to the institution of the block system. This should be followed by regular conferences at which all may receive and exchange information and thus obtain a better understanding of all operations. This will assist in the prevention of misunderstandings.

6. If spawning operations are conducted to procure stock, the block leaders should have the opportunity to supervise these operations in order to see that the eggs entering their respective blocks are of suitable quality.

7. Monthly comparisons of food conversion into pounds of fish, gain in weight, mortality, etc., should be made to show the block leaders how each block of fish is progressing. Some recognition could be made to foster competition. A block leader should not be penalized, however, if lack of progress is due to conditions beyond his control.

ACKNOWLEDGMENT

The writer gratefully acknowledges the assistance of all Coleman Station personnel in the initial trial of the block system, their suggestions for its greater efficiency and successful use in the present operations at the Coleman Station. The approval and assistance of Mr. John Pelnar, District Supervisor, and Mr. A. C. Gastineau, Hatchery Superintendent, made possible this trial of the system.

SPAWN FROM

LAKE SAN CRISTOBAL

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At an elevation of 8,997 feet, Lake San Cristobal in the San Juan Range is one of the highest lakes at which egg-taking operations are now conducted. About 2 miles long, from 1/4 to 1/3 of a mile wide, and 80 feet deep in some places, this lake provides excellent brook-trout fishing.

The U. S. Fish and Wildlife Service maintains an egg-collecting station at Lake San Cristobal. Formed years ago by slides from Cannibal Mountain into Lake Fork of the Gunnison River, this lake is usually covered with ice 5 months of the year. Few but fish-culturists approach San Cristobal in winter, when snow slides, subzero weather, and ever-thickening ice are continuous hazards whether travel is from Gunnison by Lake Fork Canyon or from Creede by way of Spring Creek Pass (10,COO feet) and Slumgullion Pass (11,357 feet at the crest of an abrupt rise from the lake).

Ice on the lake is 12 to 14 inches thick before the end of the egg-taking season. Each night there is a 2- or 3-inch freeze to be chopped from the holes made during the seining activities shown in these pictures.

Several yards from the bank of the lake, a crew of two or three men chop a series of 2-foot holes in the ice beyond the outer edge of a spawning bed. At one end of the spawning bed, a hole about 3 by 5 feet is cut in the ice for the entrance of the seine. From one hole to the next, a long pole with a rope from the seine attached--like a giant needle

and thread--is pushed under the ice. When the seine has been drawn under, holes are chopped in the ice from either end of the seine to the shoreline and the rope is threaded to the shoreline by means of the pole. From the end of each row of holes, an open channel is cut adjacent to the shore. An 8- by 6-foot opening in the middle of this channel gives room to land the seine and the haul of brook trout.

Six beds are seined each day, producing as many as 12 tubfuls of trout to a seine on days when the haul is good. The tubs of trout--most of them are 9- to 10-inch fish--are hauled by sled to centrally located holding pens or live boxes. When the fish are ripe, they are stripped by men standing in freezing water. To keep the eggs from freezing to the spawn pan, it is kept in another pan of water. The 10-gallon oak kegs in which the eggs are finally placed for transportation to the hatchery, are likewise kept in water.

From 2 million to 3 million eggs are taken during this season from some 12 thousand females. There are only about 250 eggs per fish in this lake, but the 97-percent eye-up provides a high return.

ESTABLISHMENT OF "STREAM-FEEDERS" AS A MEANS OF CONSERVING FISH

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SINCE MOST streams are not capable of manufacturing their own basic food materials, they must depend upon outside sources for these essential elements. For this reason, it is not possible to consider a stream course as an isolated unit but only as part of that unit, the remaining parts being the ponds and the marshes which are, in at least a small way, connected with the main channel.[1]

The factors of a running-water environment are so severe that often a goodly portion of the smaller animal and plant life is removed from the stream; so unless there was constant "restocking" from connected ponds and marshes, the water would not be capable of supporting much fish-life. The findings of Kofoid, in his work on the plankton of the Illinois River (1903), indicate that the qualitative features are determined to a large extent by factors in the environment.

Krieger (1927) definitely believes that the organisms commonly found in rivers originate from four possible sources: (1) the area surrounding the river headwaters; (2) the limnoplankton from lakes along the river; (3) heleoplankton from pools along the river; (4) tributary streams and drains.

[1]"Pond" is considered as a distinct ecological unit, not as a term describing the retardation of stream flow by physical means. This retarding and impounding of waters is often called "ponding."

*Mr. Masters is doing some graduate work at Western Reserve University, expecting to receive his Ph.D. in water biology.

Needham, in his work on streams of central New York (1930), describes how fishes in streams tend to seek impounded waters, areas which also act as reservoirs for catching and maintaining smaller animals that are washed downstream. The value of higher aquatic plants as a factor in increasing the productivity of a stream has also been discussed. In his book on limnology (1935), Welch brings out the effect of impoundment on the productivity of the water.

It is generally assumed that the lotic plankton is not a group of organisms adapted to life in running waters to any special degree, but very few scientific data have been secured to prove much. There does seem to be a general dominance of the phytoplankton over the zooplankton.

Although, as stated before, there is really not much known about the origin of river and stream plankton, records indicate that the plankton comes from the uppermost tributaries, the headwaters of the stream, and not from the main channel. Kofoid's conclusions are that the plankton of the Illinois River channel does not come directly from the tributaries but from the impounding backwaters. Galtsoff (1924) arrived at the same conclusions concerning the Upper Mississippi River. Reinhard's work (1931) indicates that the number of organisms which are capable of living in the main channel of rivers are relatively few compared to those living in the more sluggish tributary waters.

To a limited extent, the remarks made concerning plankton in running waters would also be true of the higher forms of life such as amphibia, crustacea, and

the higher aquatic plants which are so very necessary for the welfare of fish in lotic environments.

The problem of a diminishing food supply for our stream fish is becoming more and more evident. The hazards of current, molar agents, floods, droughts, varying water level, ice action, and other factors characteristic of lotic environments--conditions which are responsible for a large part of the sterility of our streams--have been so increased by man that on some waters the original biota upon which fish feed is practically extinct. Records show that the natural food is generally insufficient to produce maximum growth of fish in some streams, and as food shortage is probably one of the most common and most serious of the factors limiting fish production, man should therefore devote much of his attention toward solving that problem.

Stream-improvement work for the purpose of increasing the food supply of fish--including the retarding of stream flow by means of stone and brush retards and deflectors, the building of dams, construction of shade areas, elimination of excessive acidity or alkalinity, installation of sufficient cover, and the fertilizing of water--is usually quite helpful and should be encouraged. There are some streams, however, that are not responsive to that kind of treatment, and the establishment of connected feeders at the headwaters of these waterways is suggested.

These production centers would be controlled so as to serve two definite purposes:

A. Managed production of food organisms, primarily.
B. Managed production of game fish for restocking of the lower waters, secondarily.

The food organisms to be produced could include daphnia and other closely related Entomostraca, Gammarus, Hyalella, Palaemonetes, crayfish, tadpoles, and forage fishes. In any event, the establishment of such centers would eliminate to some extent the necessity of transporting live game and forage fishes to stocking sites. This would be a saving in itself. It would also mean less financial loss from the death of fish en route and would eliminate much labor.

Stocking could be done during the warmer months as well as during the cool ones, as all it involved would be the opening of a valve and the flowing of the contents of the "generator" ponds into the stream. Routine work would consist of the release of the pond's contents at the time when it had reached its greatest biological productivity, and would, therefore, be a more efficient system of handling produced crops.

The crops raised in each area could be controlled so that their release would be in a definite order to fit in with the cycles present within the stream waters. Daphnia would be released when they were most needed by young fish in the lower waters, tadpoles and crayfish would follow, and finally forage minnows would be released.

There is little doubt that there are many streams that would respond in an ideal manner to the addition of stream feeders. These waters could be designated as "type" areas, such as smallmouth-bass areas, sunfish areas, and others; and the feeding centers could be adjusted to supply the needs. A smallmouth-bass stream would require three releases per year from the headwater feeding station: the first would be made in May, when a flow of daphnia would be released; the second, consisting of tadpoles and crayfish, would come in July; a third in September would consist of minnows.

The preparation of such areas need not be expensive, as it would be essentially the elaboration of conditions already present, involving the digging of shallow ponds and the construction of release valves. Process required would vary according to the character of the water supply and watershed; it need not require anything so elaborate as the most simple of State fish farms. One man could manage successfully all the areas in one average county.

Before any steps could be taken in construction and maintenance work, it would be necessary to select a good site, one which would serve the largest area in the most efficient manner. Primarily, the altitude of the site should be such that it is located at the source or headwater area of the stream. At the same time, it is necessary that the location

be not so high that water is accessible only during part of the year. Some streams may offer a location such that an area could be established quite far downstream, the drainage to be made into a tributary stream of the main channel. After the general location is decided upon, a more specific site should be selected.

The most important factor to consider in this final decision is the proximity of the area to the stream. Here a permanent waterway to the main channel would be essential. Other factors to be considered are the contour of the land (the most serviceable permitting a gravity-flow of the water) and the water supply, which should be fairly constant and free from pollution. Proper management requires that all intakes and outlets be securely screened and that complete and rapid drainage be possible. At least three ponds would be constructed in each area for use as follows: (1) entomostracans, (2) crayfish and tadpoles, and (3) forage fish.

In addition to their value as dispersal areas for food, some of the propagation centers could be utilized as a base for the dissemination of aquatic plant seeds, tubers, and hibernaculae, which could be grown along with the other crops at little additional cost. This work would be limited to those areas which are naturally wet, as it would not be recommended to attempt to grow animal and plant crops together in the same ponds. Such plants as Zizania, Vallisneria, Potamogeton, Chara, Sagittaria, Sparganium, and Elodea, could probably be grown, harvested, and dispersed in this manner.

A more simple but much less effective application of this idea would be the location of natural production centers such as oxbow ponds and impounded brooklets which could be drained quite easily into streams at regular intervals. Proper diversion of the inflowing water around the pond would be necessary, fertilizing and restocking would follow drainage, and the practice would be continued each year or so. This would really help Nature to help herself--the best kind of conservation.

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COD-LIVER OIL IN THE DIET OF TROUT

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IN 1938, as part of a program of investigation of the problem of diets for hatchery trout, under the direction of Dr. H. S. Davis, In Charge, Aquicultural Investigations, a mixture of liver and fish meal was compared with a mixture of liver, fish meal, and cod-liver oil (3 percent) as the diet of fingerling rainbow trout. Food conversion and growth on the diet including cod-liver oil were so much superior (Gutsell, 1939) that experimentation with cod-liver oil was continued in 1939, 1940, and 1941. It is thought that the results will prove of interest to fish-culturists.

The data obtained with fingerling trout from 1938 to 1941 form the basis of this brief paper.

Experimental Results

Data from the various trials are given in table 1. The table includes information as to species, initial number of fish per trough, time (year) and duration of trials, initial and final average weights of fish, gains in weight, mortality, food conversion, cost of food per pound, and cost of food per pound of gain in weight ("cost of production").

In every one of the 14 comparisons, growth (both for the period of trial and on a daily basis) was greater on the diet including cod-liver oil (3 percent). Growth of rainbow fingerlings for the period of trial averaged about 19 percent (7.3 grams per fish) greater with cod-liver oil in the diet.

Conversion of the diets including cod-liver oil was superior in 11 of the 14 comparisons, equal in 1, and slightly inferior in 2 comparisons (conversion factor of 2.72 and 2.73, as compared with 2.69). The superiority in conversion of diets including cod-liver oil reached a maximum of 22 percent (1.22 times as good). The total amount fed (565,145 grams) divided by the total gain (207,039 grams) gives an average of 2.73 pounds fed per pound gained (or grams fed per gram gained), or "conversion factor" for diets including cod-liver oil. Dividing total gains (207,039) by total amount fed (565,145) gives 0.366 for the gain as a decimal fraction of the amount fed, or "conversion rate." For the controls, corresponding statements are: 529,407 divided by 181,719 equals 2.91 (conversion factor); and 181,719 divided by 529,407 equals 0.343 (conversion rate). Division of 0.366 by 0.343 shows that the conversion of the diets including cod-liver oil averaged 6.7 percent better than (or 1.067 times as good as) the conversion of the diets that did not include cod-liver oil. According to analysis of covariance, this superiority was "significant," almost "highly significant."

In most trials, cost of production was lower with cod-liver oil in the diet.

With yearlings and older fish, conversion and growth (on the average and in most comparisons) were better with cod-liver oil in the diet. Unfortunately, unaccounted losses of fish in pools, as from birds, make close distinctions difficult. According to analysis of covariance, conversion by yearlings and older fish was not significantly better where cod-liver oil was included in the diet.

Except for the brown trout and for trout fed diets the meat portion of which was pork spleen, or the dry portion of which was meat meal, mortality for 141 or more days was less than 1 percent. In the

TABLE 1.--Diets without ("Plain") and with cod-liver oil (3 percent)

Plain or C.L.O.	Meat	Main dry portion 1/	Average weight grams Initial	Average weight grams Final	Gains per fish Per trial Grams	Gains per fish Per trial Percent	Gains per fish Per day mlgms	Mortality through trial percent	Pounds of food per pound of gain Dead excluded	Pounds of food per pound of gain Dead included	Cost per pound Gain Diet	Cost per pound Gain Dead included
			Initial number rainbow fingerlings per trough, 500; trial period, 166 days (1938)									
Plain	Sheep liver	White fish meal	2.6	37.3	34.7	1335	208	0.4	3.16	3.15	$0.074	$0.233
C.L.O.	"	"	2.4	44.0	41.6	1733	249	0.0	2.77	2.77	0.0758	0.210
			Initial number rainbow fingerlings per trough, 400; trial period, 141 days (1939)									
Plain	"	"	3.8	43.0	39.2	1032	278	0.8	2.93	2.91	0.075	0.218
C.L.O.	"	"	3.6	45.1	41.5	1153	294	0.0	2.74	2.74	0.0768	0.210
Plain	"	"	3.5	41.7	38.2	1091	271	0.0	2.97	2.97	0.083	0.247
C.L.O.	"	"	3.7	46.2	42.5	1149	301	0.2	2.98	2.97	0.0845	0.251
Plain	"	"	3.7	45.4	41.7	1127	296	0.0	3.00	3.00	0.0816	0.245
C.L.O.	"	"	3.6	49.2	45.6	1267	323	0.0	2.77	2.77	0.0832	0.230
			Initial number brown fingerlings per trough, 400; trial period, 141 days (1939)									
Plain	"	"	1.3	16.2	14.9	1146	106	0.8	3.18	3.16	0.083	0.262
C.L.O.	"	"	1.2	19.8	18.6	1550	132	2.8	2.65	2.60	0.0845	0.219
Plain	"	"	1.2	18.6	17.4	1450	123	2.8	2.72	2.69	0.0816	0.220
C.L.O.	"	"	1.4	22.6	21.2	1514	150	3.2	2.76	2.72	0.0832	0.226
			Initial number brook fingerlings per trough, 400; trial period 141 days (1939)									
Plain	"	"	4.2	48.0	43.8	1043	311	0.2	2.79	2.78	0.083	0.231
C.L.O.	"	"	3.9	53.8	49.9	1279	354	0.8	2.61	2.60	0.0845	0.220
Plain	"	"	3.9	51.6	47.7	1223	338	0.5	2.66	2.65	0.0816	0.216
C.L.O.	"	"	3.8	54.8	51.0	1342	362	0.5	2.61	2.61	0.0832	0.217
			Initial number rainbow fingerlings per trough, 300; trial period, 141 days (1940)									
Plain	"	L-40-A	4.3	54.6	50.3	1170	356	0.3	2.80	2.80	0.069	0.193
C.L.O.	"	"	4.3	61.8	57.5	1337	408	0.0	2.63	2.63	0.0709	0.186
Plain	"	"	4.3	50.1	45.8	1065	325	0.7	2.89	2.88	0.068	0.196
C.L.O.	"	"	4.2	60.8	56.6	1348	401	0.0	2.59	2.59	0.071	0.184
Plain	"	Meat meal	4.2	48.5	44.3	1055	314	3.3	2.75	2.69	0.0665	0.179
C.L.O.	"	"	4.0	56.2	52.2	1305	370	27.0	3.21	2.73	0.0685	0.187
Plain	"	"	4.1	48.6	44.5	1085	316	2.0	2.73	2.70	0.0655	0.177
C.L.O.	"	"	4.0	58.2	54.2	1355	384	20.3	2.96	2.66	0.0675	0.180
			Initial number rainbow fingerlings per trough, 285; trial period, 143 days (1941)									
Plain	Pork spleen	C-12	4.1	27.3	23.2	566	162	1.8	3.68	3.66	0.05	0.183
C.L.O.	"	"	4.0	36.2	32.3	808	226	2.8	3.06	3.03	0.0525	0.159
Plain	"	"	4.2	29.9	25.7	612	170	1.8	3.52	3.49	0.05	0.174
C.L.O.	"	"	4.2	41.3	37.1	883	259	3.2	3.03	3.01	0.0525	0.158

The cod-liver oil diet is always to be compared with the "plain" diet immediately above it in the table.

1/ A small amount (3.0 percent) of kelp meal was included in some of these diets; in such cases always in both the "plain" diet and that including cod-liver oil (C.L.O).

four comparisons involved in these exceptions, mortality was higher with cod-liver oil in the diet; in the case of meat meal, a great deal higher. Whether the combination of meat meal and cod-liver oil is dangerous or the high loss coincidental, is not known. Certainly there is nothing in the data to indicate that cod-liver oil inclusions improved the health.

Discussion

That the diets including cod-liver oil are superior for food conversion and growth, is clear; the property of cod-liver oil responsible for that superiority, not so readily apparent.

Vitamin A was considered, but it was found that a diet including corn-salad oil fortified with vitamin A did not produce better growth than the same diet with the corn-salad oil unfortified and presumably sensibly free of vitamin A. Moreover, it has been reported (Phillips, et al, 1940) that cod-liver oil in the diet had very little effect on vitamin A storage in trout. Thus vitamin A seems ruled out.

If the apparent difference in the value of dietary inclusions of cod-liver oil, between fingerlings and yearlings or older fish, is real and not due to unaccounted losses in the pools or other "outside" difficulties, it seems that the improvement with fingerlings, or a part of it, may have been due to the vitamin D in the cod-liver oil. The fingerling experiments were run in hatchery troughs which did not receive direct sunlight and were fed through a pipe from an enclosed (covered) spring. Yearlings and older fish were kept in outdoor pools, where the fish and perhaps an appreciable amount of small food organisms were subject to solar radiation. Thus these fish possibly were in less need of dietary vitamin D than the fingerlings.

Perhaps a more probable explanation, or partial explanation, is to be found in the high heat value (calories) of cod-liver oil. On a dry basis the 3 percent becomes something like 5.5 percent of the diet (and considerably more of the nutrients). Being a digestible fat, its heat value would be equal to 2.25 times 5.5, or 12.375 percent. Thus, the increase in calories would be some 7 percent or more (12.375 - 5.5 = 6.875, but presumably a considerable portion of a diet is not digested and, therefore, the percentage would be considerably more than 6.875). The fact that no improvement in health was found favors this hypothesis, and it seems that at least a considerable portion of the improvement was due to the high digestibility and heat value of the oil.

It is interesting to note that the improvement due to inclusion of cod-liver oil was greatest in the case of a diet of comparatively low growth-producing power, composed of spleen and a dry mixture (C-12: equal parts of fish meal, dried skim milk, cottonseed meal, and flour middlings, plus salt) rather low in proteins, especially animal protein.

During the War, cod-liver oil became difficult to obtain. Where and when its relative price is sufficiently low, this oil offers a favorable opportunity for improving trout growth.

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FISH PRODUCTION PROGRAM, 1947, IN THE SOUTHEAST

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THROUGHOUT the States of the Southeast, or Region 4, farm fishponds have become more and more popular during the last few years. At the close of the 1946 distribution season, it was evident that the rapidly increasing number of applications for farm-pond fish would require drastic changes in the production program for warm-water species during 1947.

The first change in the regional program was the elimination or curtailment of production of those species for which few applications were being received: production of catfish, crappie, rock bass, and warmouth bass was eliminated; production of red-eared bream and smallmouth bass was greatly reduced. At many of the stations only largemouth bass and bluegills were produced. By eliminating some species and curtailing production in others, the acreage for producing largemouth bass and bluegills was increased by approximately 10 percent. This greater emphasis upon fewer species simplified station production operations and distribution problems.

Study of previous production methods at the stations revealed that many had been stocking ponds with adult bass and adult bluegills; that is, combination ponds were drained in the fall and both bass and bluegills were distributed at the same time. By this system, these stations produced relatively few bluegills per acre and distributed comparatively large fingerling bass, and the procedure in general tended toward inefficient operations. This method of stocking ponds and distributing fish was eliminated in all but a few stations. During the early spring months, sufficient ponds were allotted to produce the bass necessary to take care of the application load. This apportionment was based upon the expectation of completing the bass distribution during the first half of the year. Bass were distributed while they were small; many of the applications were filled with fish approximately 1 inch long, many of which came from the brood bass ponds. Bluegill distribution was scheduled for the last half of the year, and many ponds which had been used for producing an early crop of bass produced one or more crops of bluegills during the remainder of the year. This created two distinct distribution seasons.

An important measure in the over-all program was a review of the pond water supply at the stations. A fertilizer mix considered suitable for the particular waters was recommended and used where it was obtainable. A definite fertilization program was established for the project leaders to follow.

Early in the year, project leaders were requested to submit a schedule outlining the production program contemplated for the year. The program was to be based upon meeting their anticipated application

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Southeast, as used here, refers to the States of Kentucky, Arkansas, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana, which are administered as Region 4 of the Fish and Wildlife Service.--EDITORS.

load if possible, and upon producing a definite number of fish for transfer to other points if station potential allowed. Project leaders were requested to indicate the stocking rate they intended to use with adult bluegills. When the production schedules were reviewed, the majority were revised to increase the number of adult bluegills which were being used per acre for stocking purposes. The goal set was to stock ponds at 100 bluegills per acre unless special conditions governed. Frequently, sufficient adult bluegills were not available to meet such a high stocking rate. In general, however, the number of bluegills used per acre was increased throughout the Region.

BASS PRODUCTION

Because fewer bass (in comparison with the bluegills) were required, bass production was relatively simple and did not create a serious problem. As the demands for bluegills have increased to such an extent during the past few years, however, and there have been indications that at least two crops of this species might be required from many of the hatchery ponds, some experiments were conducted during the year to increase bass production per acre. These efforts were based on the production of bass in rearing (or, as we prefer to call them, holding) ponds to a size suitable for distribution to farm ponds. (The necessity for producing such bass in rearing ponds is due to the fact that distribution trips cannot be arranged in advance with the expectation of collecting the young fish from the brood ponds. The only way the project leaders at many stations can be sure of having bass available on the date set for distribution is to have rearing or holding ponds.) In order to save space, it was desired to produce large numbers of bass per acre of pond space. The aim was to produce fingerlings 1¼ to 1½ inches in length. This size was chosen because such bass may be expected to stand handling reasonably well during pond-draining operations and are nice fish to distribute to farm ponds. Meehean's weight-length chart for bass gives a weight of 4 ounces per hundred for 1½-inch bass. On this basis, 40,000 1½-inch bass would mean a production of 100 pounds per acre. Experiments conducted by Meehean several years ago showed that bass ponds properly prepared and stocked suffer no appreciable mortality in fish from the time the fry are introduced until the pond is drained. In determining the number of bass fry with which to stock ponds, we extended Meehean's production chart and assumed a possible maximum production of 100 pounds per acre. Tests were arranged at a number of stations using these high stocking rates. Although there were a number of failures, the reasons for these failures were quite evident. Experience gained through these failures is considered valuable for its assistance in avoiding the same mistakes in future.

Some of the tests undertaken were as follows:

At Tupelo, Mississippi, three ponds were stocked at the rate of 40,000 fry per acre. These ponds were well fertilized with barnyard manure early in the season, and an inspection of the ponds just before the bass fry were introduced revealed that daphnia and related organisms were plentiful. The ponds were drained when the bass were approximately 1¼ inches in length. Production ranged from slightly less to slightly more than 40,000 bass per acre. As three ponds were involved and all produced at the rate of approximately 40,000 per acre, it seems quite feasible to produce at this rate bass of a size suitable for distribution. This heavy production can be secured only from those ponds which are in proper condition when the bass fry are introduced. Ample evidence of this was indicated in other tests made during the year. Poundage secured from the Tupelo ponds was low, averaging approximately 30 pounds per acre. Owing to the low poundage secured, it seems likely that maximum production in numbers has not yet been secured for this size bass.

At Corning, Arkansas, a number of ponds were stocked at 40,000 fry per acre. Normally productive, the Corning ponds were reasonably well fertilized. Production from the Corning ponds ranged from 30,000 to 39,000 per acre, the fish running from 1¼ to 1½ inches in length.

Although the Corning ponds are normally more productive than those in most of the other stations in the Region, production secured was not considered entirely satisfactory. It is believed that earlier fertilization of the Corning ponds would permit greater production.

At Edenton, North Carolina, a number of ponds were stocked with 50,000 fry per acre. As pond water at the Edenton Station has a pH of 6.2 (apparently caused by humic acid), these tests were set up primarily to determine the best type of fertilizer to use. The fact that the pond water is on the acid side is sufficient to indicate that the ponds would be low producers. Three methods of fertilization were tried in these Edenton ponds. One method involved the use of all organic fertilizer, which consisted of barnyard manure. Another pond was fertilized with a combination of organic and inorganic fertilizer. Another pond was fertilized with inorganic fertilizer. The Edenton ponds were drained when the fish were relatively large in comparison with those produced at Tupelo. Production ranged from 15,000 to 20,000 1½-inch bass per acre. Poundage production was much better than that of the Tupelo Station. Results of the Edenton test provided valuable information as to the type of fertilizer to use in acid waters. There is reason to believe that production in numbers can be much greater than this year's results indicate: the poundage secured under adverse conditions was reasonably good, and the size of the bass produced this year was larger than required for distribution purposes.

At Natchitoches, Louisiana, a test was arranged late in the spring. Because of the late date at which this test was begun, there was not sufficient time for proper fertilization. Production was relatively low, amounting to 23,000 1½-inch bass per acre.

At Orangeburg, South Carolina, where stocking was at the rate of 40,000 fry, production in a test was at the rate of approximately 36,000 per acre.

From the heavy bass-stocking tests which were conducted during the year, it has been concluded that at least 40,000 bass fingerlings of suitable size can be produced per acre of holding or rearing pond. It is assumed that the ponds would be properly fertilized early enough to produce ample food in the ponds by the time the bass fry are introduced. The bass fry must, of course, be uniform in size when placed in such ponds.

BLUEGILL PRODUCTION

Because bluegill production has undergone a number of changes (any one of which might contribute to the increase in bluegill production this year) and complete data are not yet available, it would be difficult to assign a definite amount of credit to any one factor at this time. Approximately 11,000,000 bluegills were produced in the Region last year. Average production per acre was 43,000. During 1947 production should be more than double the total production secured during 1946. In order to evaluate the possibilities of bream production, the following examples are given:

At Corning, Arkansas, ponds were stocked with 90 adults (average weight, 8 ounces) per acre. Ponds received good fertilization. The production averaged 143,000 fingerlings per acre, and these weighed 15 to 20 ounces per thousand. This size is considered ideal for distribution.

At Cohutta, Georgia, ponds were stocked with 40 adults per acre. A total of 7.26 acres produced 911,000 fingerlings, which weighed 30 to 60 ounces per thousand. This is larger than the size required for distribution purposes. An uncertain number of ponds produced two crops of bluegills. The project leader recommends increasing the number of adults to 50 to 60 per acre to increase the number of fingerlings and secure more uniform size.

At Lyman, Mississippi, the stocking rate was 400 adults per acre. Production was 250,000 per acre and up. The fish produced weighed 8 to 20 ounces per thousand. Heavy fertilization and feeding were used, and the trapping was intensive.

At Natchitoches, Louisiana, one experimental pond was stocked with 200 adults per acre for two-crop production of bluegills. The first crop, secured August 1, totaled 57,000 No. 1 bluegills per acre.

The second crop, secured December 26, totaled 155,000 No. 1 bluegills which weighed 156 pounds. This pond was well fertilized.

At Edenton, North Carolina, ponds were stocked with adults at varying rates. The highest production was secured with 82 adults per acre, which produced 57,000 fingerlings per acre. The lowest production, 21,000 fingerlings per acre, was secured where 18 adults per acre were used. All ponds were well fertilized.

At Carbon Hill, Alabama, ponds were stocked with approximately 100 adults per acre. Production ranged from approximately 260 to 360 pounds per acre, representing an average of 147,000 fingerlings per acre, based on 7¼ acres. The fertilization program was considered fair.

At Marion, Alabama, ponds were stocked with 70 to 80 adults per acre. No fertilizer was used. Production averaged 80,000 fingerlings per acre, and these weighed 10 to 30 ounces per thousand.

At Mammoth Spring, Arkansas, ponds were stocked with 50 large adults per acre. Quite a number of these fish weighed 20 ounces or more each, the largest weighing 30 ounces. Production was approximately 100,000 per acre, the fish weighing 15 to 20 ounces per thousand.

As may be noted, a production of 100,000 or more fingerlings per acre has been attained in a number of tests. With the exception of the Cohutta Station, this production has been secured in one crop. Where high production was secured, adult stocking was relatively high or, as at Mammoth Spring, the adults were unusually large. We do not have good information concerning production per acre where relatively low numbers of adult brood fish per acre were used. The best indication we have on this would be the results secured at the Tupelo Station. There is reason to believe that in the one pond which received best fertilization, the 30 adults produced approximately 80,000 young: at an early age some of the young escaped into another pond, and this accounts for the actual production being listed at 60,000 per acre. There is sufficient evidence from other sources to indicate that production of 160 pounds per acre of fingerlings weighing about 1 pound per 300 fish, might be considered good production where ponds are stocked with brood fish at the rate of approximately 30 per acre. This would represent approximately 50,000 fingerlings per acre. Where 100 adults have been used, the fingerlings produced have been relatively small though large enough to handle well. This year tests are being arranged at a number of stations to determine the production which can be secured from various stocking rates.

CONCLUSION

We attribute the heavy increase in production of bluegills to the following changes in procedure:

1. The increase in pond acreage devoted to the production of this species, an increase made possible by the elimination of those species not required.
2. The elimination of combination stocking of brood fish.
3. Better fertilization methods.
4. The increase in the number of adult bluegills per acre used for stocking brood ponds.

As previously indicated, we do not have sufficient data available at this time to allow us to evaluate properly the factors mentioned. When complete information is received from the stations, a better and more complete analysis can be made.

REMOVAL OF EXCESS NITROGEN IN A HATCHERY WATER SUPPLY

Robert R. Rucker
U. S. Fish and Wildlife Service
Seattle, Washington

and

Edward M. Tuttle
U. S. Fish and Wildlife Service
Leavenworth, Washington

The water system at the U. S. Fish-Cultural Station, Leavenworth, Washington, has been supplemented with two wells that were to be used to increase the temperature of the water during the winter and to cool the water in the summer if necessary. The well water proved to be unsuitable for hatchery purposes because it was supersaturated with nitrogen, causing "gas-bubble" disease among fish subjected to it. Mr. R. E. Burrows, the district biologist at the Leavenworth laboratory, devised a system by which the water from one well could be used satisfactorily in the hatchery after a circuitous routing through a mixing chamber with considerable agitation and a settling basin. The circuitous routing precluded the use of the rearing ponds, and it did not sufficiently reduce the nitrogen tension of the water from the other well.

Recently need has arisen for additional water and the rearing ponds at the Leavenworth Station; hence it has been necessary to construct a deaerator in the direct line from the wells to the hatchery. As the deaerating device has been satisfactory, the writers believe that others who face a deaeration problem may be interested in the design and the results obtained.

As shown in figure 1, the water flows in thin sheets from two slot orifices extending the length of a supply conduit. From the opening on either side of the conduit, the water drops 10 inches into a trough 8 inches wide, 8 inches deep, 10½ feet long, and constructed to accommodate a flow of 2,000 gallons per minute. From this trough the water falls 9½ inches into a second trough. This procedure

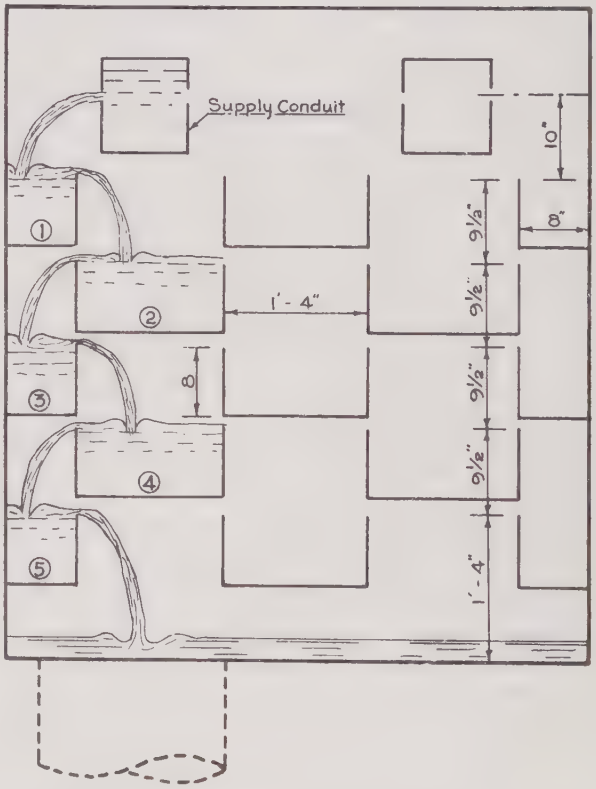


FIGURE 1.--Removal of nitrogen involves passage of water from the two wells into 13 troughs, a settling basin, and finally the hatchery troughs.

is repeated through a third, fourth, and fifth trough, until finally the water spills onto the bottom of the deaerator, from which it drops 4 or 5 feet into the settling basin of the regular water supply. The rate of water flow during the tests was approximately 2 gallons per minute per lineal inch of spill (1,000 gallons per minute, total flow).

The results listed in the accompanying table were obtained from tests of the water from the more highly saturated well.

NITROGEN CONTENT OF WELL WATER EXPRESSED AS PERCENT SATURATION

Sampling points	Deaerator with troughs	Deaerator with shelves
Supply conduit	144	140
1st trough or shelf	133	135
3d trough or shelf	122	-
5th trough or shelf	115	117
Settling basin	104	104
Hatchery trough	101	-

All analyses were made on a Van Slyke apparatus used as in the method of Oesting (1934). The water entering the supply conduit was 144 percent saturated with nitrogen; in the first trough, 133 percent; and in the fifth trough, 115 percent. When the water fell into the settling basin, the nitrogen content had decreased to 104 percent; by the time the water entered the hatchery troughs, it was 101 percent saturated. This level is considered safe for fish, as earlier work has indicated that fish can tolerate about 110 percent saturation of nitrogen and show no evidence of "gas-bubble."

The Leavenworth deaerator was originally constructed with shelves (figure 2) instead of the troughs. Because some leakage developed, the deaerator was disassembled; when it was again assembled, troughs were installed instead of the shelves. This was done because the work of Shaw (1936) indicated that aeration was much more efficient when water fell a distance into water rather than onto a flat shelf. Shaw found that aeration was most efficient when 0.8 gallon per minute per lineal inch fell a distance of 8 inches into a water depth of 6 inches.

When the shelves were used in the Leavenworth deaerator, the water entered with 140 percent saturation of nitrogen. This nitrogen tension was slightly lower than during the tests with troughs in the deaerator, presumably because the prevailing higher water table caused less nitrogen to be forced into the water. The spill to the first shelf lowered the nitrogen content to 135 percent; by the time the water reached the fifth shelf, the nitrogen tension had fallen to 117 percent of saturation. When the water fell into the settling basin, the nitrogen content was lowered to 104 percent (the same as was later effected with the trough deaerator). These data indicate that the troughs were slightly more efficient

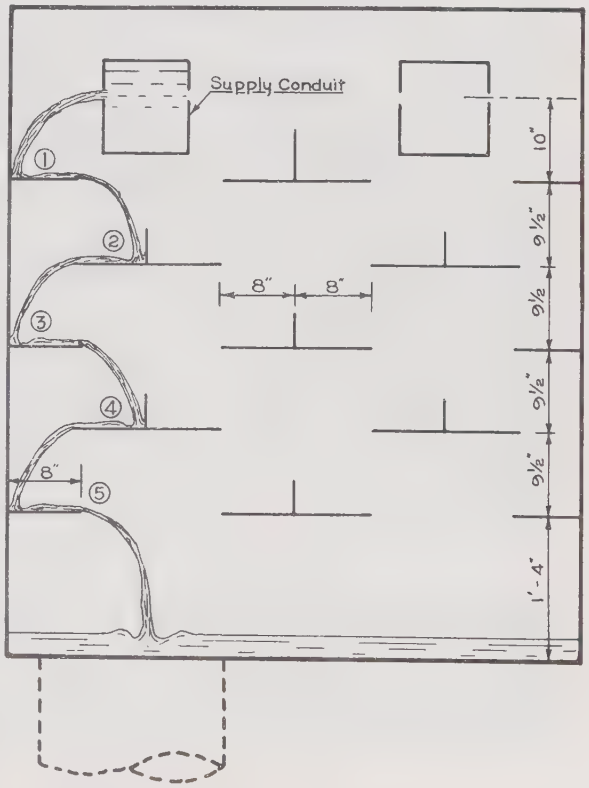


FIGURE 2.--Removal of nitrogen involves passage of water from the two wells onto 20 shelves, a settling basin, and finally the hatchery troughs.

than the shelves in effecting deaeration, although not to the extent anticipated from the aeration work of Shaw.

Experiments are now being conducted under controlled laboratory conditions for the purpose of finding a more efficient deaerator.

Oesting, R. B.
1934. A modified Van Slyke method for the determination of dissolved oxygen and total carbon dioxide in water. Physiol. Zool. 7 (4): 542-549.

Shaw, P. A.
1936. Hatchery trough aerators. Cal. Fish and Game 22 (2): 126-136.

(Photo courtesy of author)

REFRIGERATED LIVE-TROUT DISTRIBUTION TANK

James V. Stoddard
Eden Brook Trout Hatchery
St. Josephs, New York

Feeling a definite need for "fingertip" control of the conditions under which live trout are transported, the writer set about to design and construct a practically foolproof tank unit. The result is far from perfect, but the system herein described is believed to be a step in the right direction.

Mounted on an Army surplus 6 x 6 truck, the unit has a range of about 500 miles. It has successfully held 1,000 pounds of live trout for 27 hours.

See also:

Copeland, T. H.
1947. Fish distribution units. Prog. Fish-Cult. 9 (4): 193-202.

In general, the unit is similar to others that depend upon circulating pumps for aeration. A few refinements, however, have increased the efficiency to some extent. Water may be drawn from either the center of the tanks, the bottom of the tanks, or both, at the discretion of the operator.

TWO COMPLETELY SEPARATE TANKS

Each 500-gallon tank is entirely independent of the other. Different temperatures may be maintained, different water levels held, or the unit may be operated with either tank empty. The advantages of this system are several. It is possible to carry two separate shipments meant for

two bodies of water of different temperature. When the first delivery point is approached, the operator sets that particular thermostat at the temperature of the water in which the fish are to be planted. Upon arrival, there is generally less than two degrees of difference in the temperature of the water in the tank and in the stream or lake. No time is lost in equalizing.

CIRCULATORY SYSTEM

The unit is equipped with two pumps, one gasoline and one electrically driven. One acts as an emergency standby for the other. By using both pumps simultaneously and opening the drain valves in the bottom of the tanks, water may be taken in by the "filling hose connection"; this permits a complete change of water enroute in about 20 to 30 minutes.

In case of pipe-line breakage, emergency equipment is available to maintain the oxygen content until repair is completed. If it is necessary to stop for truck motor repairs, the entire system may be plugged in to any 110-115 volt (a.c.) line from an outside source, thus doing away with obnoxious exhaust fumes from the generator or pump motors.

REFRIGERATION SYSTEM

The unit uses no precooling chamber. Refrigeration plates have been placed directly in the tanks, about 1½ inches from the side walls. Screen is used to prevent the fish from being caught behind the plates. Four plates, 27 by 48 inches, are placed in series in each tank. Freon 12 is the refrigerant compressed by a Copeland 1-horsepower compressor.

It seems desirable to refer to the schematic block diagram and trace the system. The switch panel contains switches for the electric pump, the generator, the refrigeration unit, and the emergency line. Practically any combination is possible except, of course, using the mobile generator along with outside line current.

The refrigeration unit is controlled by servo switches on the refrigeration control panel.

On the refrigeration control panel the desired temperature is set manually on the thermostat control. The thermostat control switch for either or both tanks is closed and the compressor begins to operate. When the desired temperature in either tank has been reached, the thermostat throws a servo switch which, in turn, closes the high-pressure valve to that particular tank and thus stops the refrigeration from affecting that part of the load. When the temperature rises, the action is reversed. When neither tank is calling for refrigeration, the compressor automatically stops. Starting is automatic.

If only one tank is being used or if line breakage occurs, manual valves are provided on both high- and low-pressure lines so that part of the system may be inactivated.

Independent thermometers are run to the dashboard of the truck cab so that the operator may keep a constant check.

In case of refrigeration failure, ice, of course, can be used.

WINTER WEATHER CONTROL

In extremely cold regions there is always the danger of freezing a load. To combat this condition, "immersion heaters" similar to those used in Army bombers in the Arctic are employed. These electric heater units, properly protected with a screen, are lowered into the tanks and connected to the thermostats on the refrigeration control panel just as are the servo valves and switches. In below-freezing weather the water in each tank can be held at a normal temperature by using the bulk of the equipment at hand.

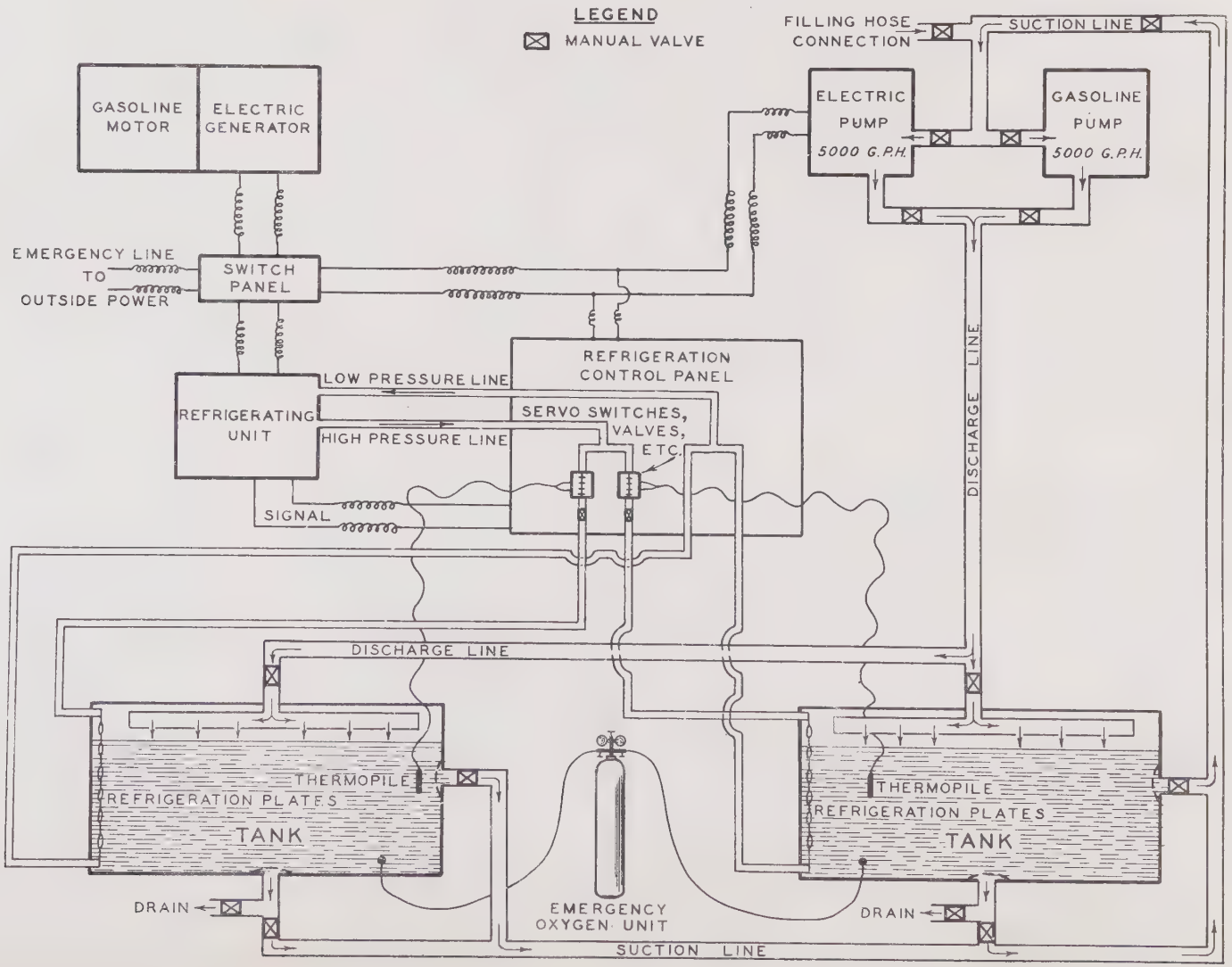
WATER CURRENT IN PLACE OF BAFFLE BOARDS

The design of the spray and suction system was based on the idea of using water current in place of baffle boards to cut down slopping.

Water is sprayed into the tank on the same side from which it is removed by the suction line. A cove in the bottom of the tank assists in setting up a rotating current in the vertical plane. This system actually divides the depth of the

TROUT DISTRIBUTION UNIT

SCHEMATIC BLOCK DIAGRAM



tank into three separate strata of water. The top third is forced away from the spray pipe, the bottom third is pulled back toward the side from which the water originally entered, while the center third is practically static. Observation has proved that the trout head into either the upper or lower current and appear to swim contentedly, going into the middle section of still water to rest from time to time. There is no conflict of fish lying head-to-head or hooking gill covers, as they swim side-by-side in the same direction. Thus, more powerful pumps than were previously employed seem in order. Water current is softer than baffle boards.

PAY LOAD PERFORMANCE

On the basis of experience with a 1,000-pound load of 8- to 10-inch brook trout carried for 10 hours, it is felt that the actual carrying capacity for this period of time is about 1,500 pounds.

On this particular trip only one pump was used, temperature was held at 51° F., and there was no loss in transit and very little vomiting. It is believed that had both pumps been put in operation and the temperature lowered to 47° or 48° F., 1,500 pounds could have been carried as successfully.

A trip into Connecticut was marred by motor trouble on the truck. One of the tanks had been emptied of trout some 4 hours before motor trouble developed. By the time repairs were made, it was too dark to commence stream planting in rugged territory and an overnight lay-over was in order. The truck and contents were parked adjacent to an all-night service station, and the emergency outside power source was plugged in. The attendants took turns sleeping and guarding the cargo against possible "fishermen." At daylight the trip was resumed, and the last trout was planted just 27 hours after the tank had been loaded. Mortality--7; pounds of live trout in this single tank--504.

Fingerling rainbow, generally subject to "after-effect" mortality, have been carried 7 and 8 hours, planted, and carefully watched for 48 hours. Only once were a few individuals observed to react unfavorably. This particular trip was made over very rough terrain that caused the tank contents to slosh considerably. In loading this size of rainbow, caution was used, however, to provide a full tank of water and to utilize only 50 percent of the normal tank capacity in trout.

CONCLUSIONS

Advantages.--

Using either source of power or the several possible combinations, this unit may be expected to meet most emergencies.

Less mobile equipment and less manpower are required to deliver large orders.

"Spread planting" may be accomplished leisurely because the trout may be held in the tanks for longer periods.

Because of the great volume of water circulation, the customary "brown scum" is never observed on the surface even after 20 to 25 hours of operation.

Selectivity of temperature negates the necessity of equalizing the temperature of water in the tank to that of the lake or stream.

This does away with "ice-house bandits" who, knowing you must have ice on the road, charge exorbitant prices.

Disadvantages.--

Size and weight of equipment make it difficult to travel woods roads and rough terrain in the mountain areas.

Vibration causes line breaks in the refrigeration system. This is being offset, it is hoped, by replacing all copper tubing with a new, practically indestructible plastic.

High clearance (10 feet) is generally necessary. The construction of a unit on a small semi-trailer is contemplated.

PIKE CULTURE

AT THE NEW LONDON, MINNESOTA, STATION

Leslie H. Bennett
U. S. Fish and Wildlife Service
New London, Minnesota

The first northern pike eggs to be taken and hatched on the battery at the New London hatchery, were taken from Green Lake, Kandiyohi County, Minnesota, in April 1941. We had been told that numerous fish came up from Green Lake to try to get into Nest Lake to spawn because Nest Lake waters were warmer at that time of the year, and we decided to experiment with the hatching of these eggs in the battery.

The northerns start to run just as soon as the ice shows signs of melting and breaking up: a few usually appear the last week of March, and the run is at its height about the 16th of April, dwindling to a dozen or so which appear with the walleyes. The walleyes continue their run until the last of April or the fore part of May.

The water in Green Lake is very deep and has few shallow places; hence it stays very cold. Nest Lake and Calhoun Lake have flats of mud and sand which make ideal spawn beds and warm up very fast after the ice goes out. Of course, the fish cannot get up into Nest Lake because of the dam between Green and Nest Lakes, but they approach the dam inlet and fight the water in order to spawn there.

We found hundreds of green, hard pike at the dam inlet. We seined up several hundred each day, keeping track of the different batches of fish in order to know the ripening periods. Into Nest Lake we put a number of holding pots, each pot containing both males and females seined during 1, 2, or 3 days.

When the water remained at a temperature of 44° F., the bucks and females began to show signs of spawning. On the first spawning date, April 10 (4 days after we had put the fish into the holding pots), we took 900,000 eggs. We took eggs each day thereafter until April 28, though the spawning was at its height on April 16 with a take of 5½ million eggs and then gradually subsided to 40,000 on May 1. The temperature of the water rose to 62° toward the end of the period. As the water warmed, the fish became more slippery, the eggs came more easily, and the bucks spermed more abundantly. Although the eggs were good until the end of the take, in the latter period the sperm became stringy and not so good for our use.

We used muck and starch to separate the eggs, finding the muck preferable for this operation. We used about a quarter of a dipper of muck water for each pan of eggs. After washing the eggs, we put them into a tub of water, where we stirred them often and changed the water. At the end of the half-day operations, the eggs were brought to the hatchery, allowed to harden for an hour, and

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See also:

Bennett, L. H.
1947. Separation of northern pike eggs. Prog. Fish-Cult. 9 (3): 169-170.

Smith, C. G.
1941. Egg production of walleyed pike and sauger. Prog. Fish-Cult. 54: 32-34.

Speaker, E. B.
1938. Pond-rearing of wall-eyed pike. Prog. Fish-Cult. 36: 1-6.

then set on the battery.

At New London we used the single battery and the Downing jars (3 quarts of eggs, or approximately 180,000 eggs, to the jar). For the first 48 hours, the eggs tended to be adhesive in the jars: they had to be watched constantly and feathered in order that they might be kept in motion. After they had hardened, this was not necessary.

As a general rule, the temperature of the battery water starts at 40° F. and rises to about 56°, 58°, and even 62° F. as the season advances. The eggs which we placed in batteries on April 10 (our first batch) eyed up April 15 and came off April 21.

Except during the egg-breaking period, the fry were very lazy. Very few worked down into the fry tank, settling instead in the bottom of the jars and lying there until removed. If the fry were left in the jars too long after the first 24-hour period, they might smother, even with a full tube feeding the jars.

We did not attempt to raise any to fingerlings in 1941, but in 1942 we prepared a 3½-acre pond and placed in it 100,000 fry to the acre. These were kept in the pond from April 18 to June 18, and 27,828 fingerlings from 3 to 7 inches long were removed. The pond was full of Daphnia when we placed the fry in it, and at regular intervals we supplied thousands of small minnows. We found, however, that the more minnows the pike received, the more the pike ate each other: with some of the northern pike, there was no discrimination between the minnows and fellow northerns. This happened repeatedly.

We learned a few things when we started to drain. The northerns did not like to follow the water down; they would keep up on the feather edge and hide in moss and algae, lying there and dying. A constant patrol was necessary to pick up as many as possible before they died, and it was a job, as these fingerlings were difficult to see until they "bellied up" and their gills were spread. Moreover, when they had been brought down around the kettle, there was the problem of getting them out before they could eat each other.

The fingerlings had to be separated at once in the tank house. Even the regular-sized northerns were not safe from the larger ones, which immediately began to assert themselves. We found it advisable to get rid of them as soon as possible, for although they were hardy, the depletion (not from fungus or disease, but from cannibalism) was apparent before long.

With help, suggestions, and ideas from various sources, we gradually improved our methods of catching, spawning, and hatching. We found wooden tubs and pails

best for use on the eggs. Northern muck was most useful for separating; starch wasn't so good, and local muck injured the eggs.

Our conclusions: Hold eggs not more than 1 hour for hardening, before setting up; let them alone in the jars for the first 36 hours, feathering only when necessary; get the fry out as soon as possible after hatching; get rid of the fingerlings at once.

WALLEYED PIKE

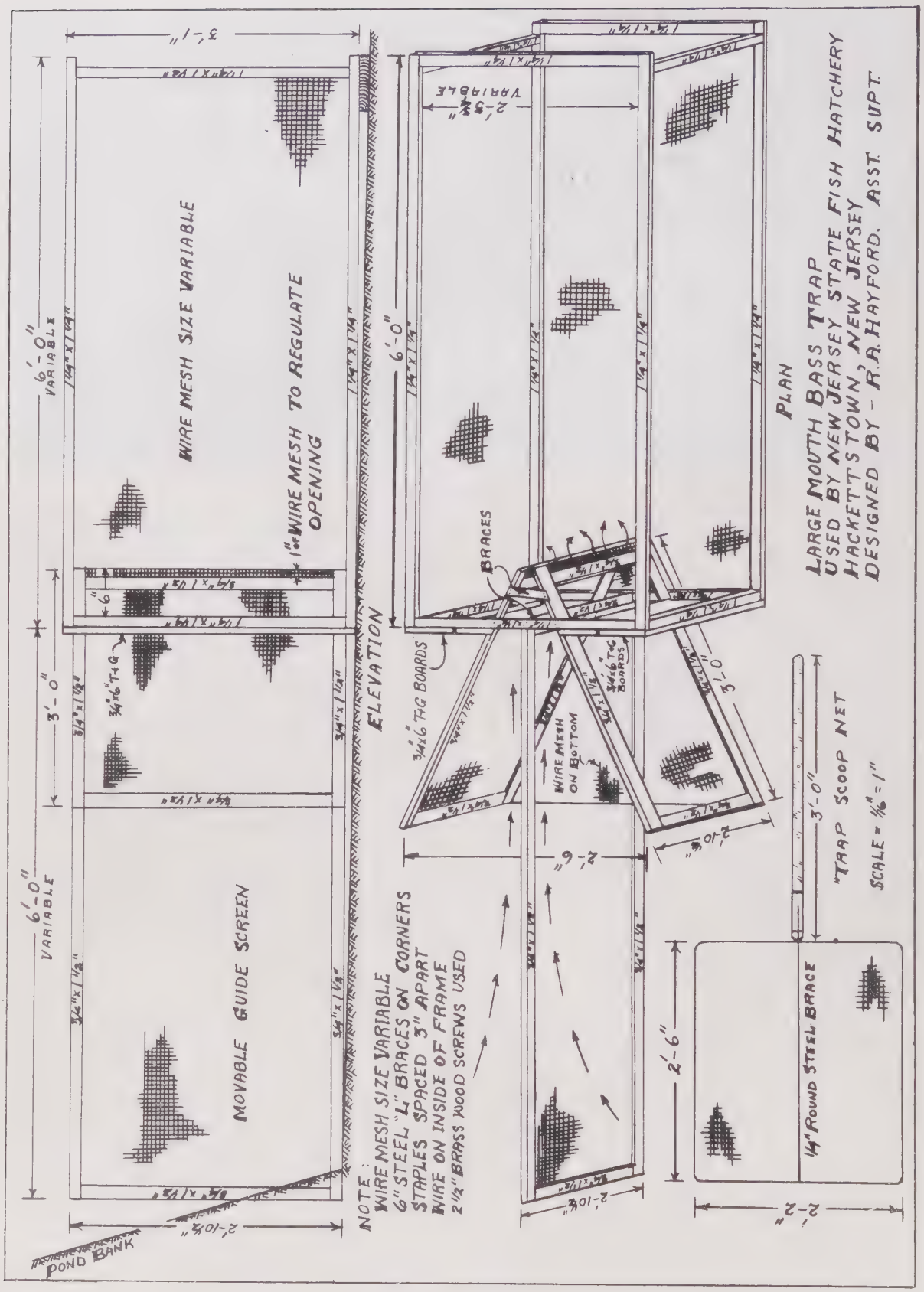
There is not so much to be said about the taking of walleye eggs. The walleyes, like the northerns, come up green; therefore, we do not hold them in captivity in pots. As the run comes up through the V's, we let them accumulate, for they are in natural habitat and do not "pink up" under these conditions as they would in a pot.

As the water warms, we seine in a few at a time and take what eggs we want. We have never taken more than 5 million, as that is all we have wanted. The eggs are of good grade, the bucks are excellent, and the hatch is as good as may be found anywhere. The fry are lively, healthy, and in fine shape.

On the last of May, we plant 100,000 to the acre in a deep, 4-acre, prepared pond. We keep a heavy, steady flow of water going in and wait; there is no use in looking for them until after the third week in June, when there will be thousands of 1½-inch fingerlings in the inlet. They play in the fresh in-coming water, feeding in schools around the pond. We begin seining them out right after the 4th of July. The only place we seine is around the inlet until they thin down; then we let them alone until we get the few left in the pond down to the kettle, where we try to get the bulk of them out, allowing the remainder to go into the kettle. It is important that the water be fouled no more than is necessary, as pike will not stand fouled water. We do not pull the pond until the bulk of the fish are out. The instinct of these walleyes is to get into fresh, cool, running water. The harder the inlet flow, the better they like it; it will not harm them, and it attracts them, making them easy to catch.

We find that when the pond is well stocked with Daphnia, the fingerlings removed will be of uniform length. We take them to the tanks and count them, keep a good flow in the tanks, and get the fish out so that they do not get thin and puny.

To restock the pond, it is advisable to return 15,000 to the acre as soon as the water is up in the pond, supply more Daphnia, throw in the minnows, and provide regularly all the live meat the walleyes will take. This should produce by September a nice crop of healthy 5-, 6-, and 7-inch fish. The walleyes require plenty of cool, deep water. If the pond is overfertilized (as ours was one year), the bloom will diminish the production of walleyes. Lastly, but by no means least, it is necessary to keep down cannibalism. This can be done by throwing the live meat to the fingerlings. Walleyes, like northerns, are natural cannibals; but at least the walleye will eat minnows--if obtainable--in preference to his own kind, whereas a northern seems to prefer his own brother.


LARGE MOUTH BASS TRAP
USED BY NEW JERSEY STATE FISH HATCHERY
HACKETTSTOWN, NEW JERSEY
DESIGNED BY - R.A. HAYFORD. ASST. SUPT.
ELEVATION
PLAN
WIRE MESH SIZE VARIABLE
1" WIRE MESH TO REGULATE OPENING
MOVABLE GUIDE SCREEN
BRACES
WIRE MESH ON BOTTOM
3/4"x6" TAG BOARDS
VARIABLE
POND BANK
"TRAP SCOOP NET
SCALE = 3/8" = 1"
1/4" ROUND STEEL BRACE
NOTE:
WIRE MESH SIZE VARIABLE
6" STEEL "L" BRACES ON CORNERS
STAPLES SPACED 3" APART
WIRE ON INSIDE OF FRAME
2 1/2" BRASS WOOD SCREWS USED

LARGEMOUTH BASS TRAP

Robert A. Hayford
New Jersey State Fish Hatchery
Hackettstown, New Jersey

During July 1947 more than 300,000 largemouth bass, 1 to 2 inches long, were taken at Hackettstown with traps of the design shown in the accompanying drawing. Whether this trap can likewise be used for smallmouth bass, remains to be seen. On the basis of past attempts to trap smallmouth bass, I do not believe that this will work too well. On the other hand, large numbers of bluegill sunfish as much as 2 inches long have been trapped.

The guide screen that diverts the fish into the V-shaped entrance to the trap, is removable; so the trap is easy to transport from place to place and to install in the pond. At the end next to the pond bank, the guide screen is supported with a stake or iron rod.

The opening in the trap can be regulated for fish of various sizes. The sides of the V-shaped entrance are frames covered with wire mesh, and on the ends within the trap this wire mesh extends 1 inch beyond the frames. These extended pieces of wire can be bent inward or outward, thereby changing the width of the opening. An opening of 1/2 inch or so is probably the most frequently used.

On each side of the V-shaped entrance the end of the trap is closed in with 3/4- by 6-inch tongue and groove boards. These reinforce that end of the trap so that it will support a plank placed from the bank to the trap. The plank makes it possible for the operator to walk out and remove the fish from the trap without wading into the pond.

The scoop net is shallow, not more than 8 inches deep. Places where the fry might get around or under the scoop net are eliminated by tacking the wire of the trap on the inside of the frame.

When there are large numbers of fish in the pond, it is well to keep the trap located where fresh water is coming in, unless the water in the pond is very high in oxygen. I trapped 1- to 2-inch bluegills in a pond that had a low oxygen content, and during the night the trap became so heavily loaded with bluegills that quite a loss resulted from an oxygen deficiency.

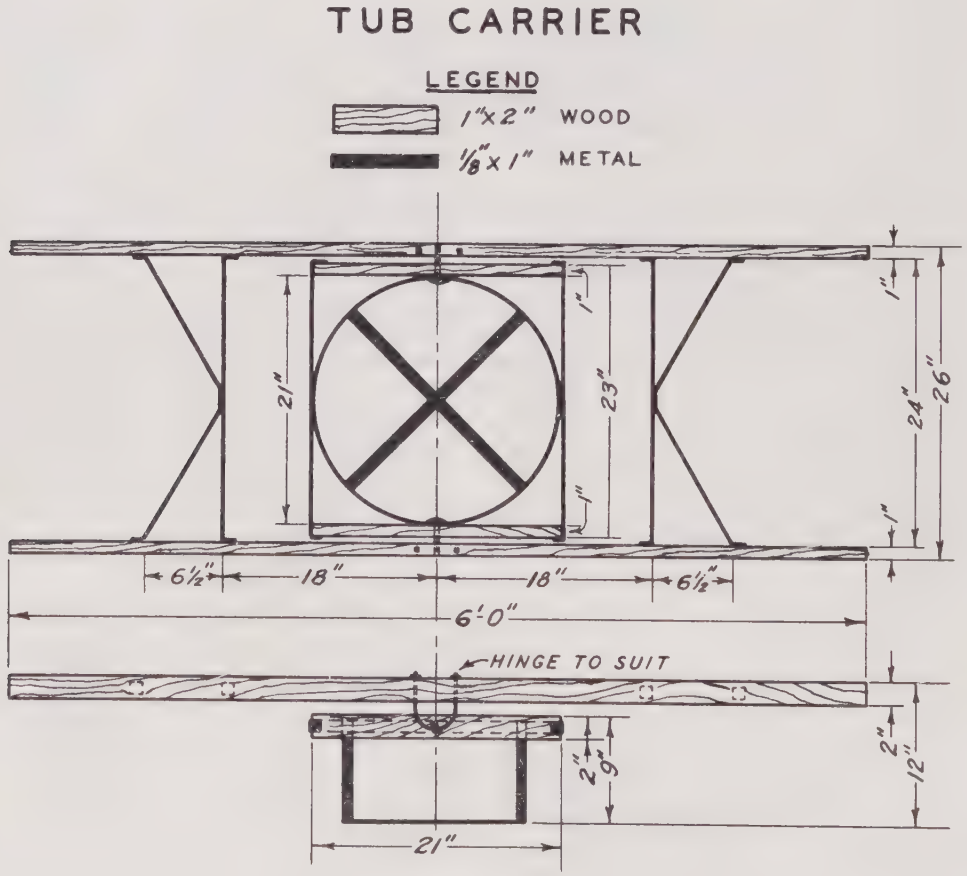
The trap was most successful in ponds in which the food was scarce and the fish were traveling along the shores to forage. The trap worked especially well when it was placed near an inlet through which daphnia were coming in with the water flow. This, of course, caused the bass to school up at that point.

FISH TUB CARRIER

S. A. Scott
U. S. Fish and Wildlife Service
Wytheville, Virginia

The U. S. Fish-Cultural Station at Wytheville, Virginia, has been built on the side of a hill. The upper and the lower stories of one hatchery building are approached directly by a flight of concrete steps laid on the side of the hill, and each of the ponds and raceways has been cut into the slope.

Tubs of fish that are to be moved between the hatchery troughs and the ponds, or from one pond to another, must be carried up or down the incline. Anyone who has moved a tub over uneven ground by means of the handles on the sides, knows the strain on the fingers and the difficulty of maneuvering the tub without spilling the contents. Station personnel at Wytheville have found it much easier to transport the tubs of fish by means of the tub-carrier.



S&M 48-1

RELATING TO PUBLICATIONS

REPRINT

PROBLEMS CONFRONTING THE MODERN FISH CULTURIST

The Pennsylvania Board of Fish Commissioners has used fertilizer in the growing of bass and other warm-water fish for a great many years. The procedure in the past, in so far as bass are concerned, was to use the fertilizer in separate pools for the growing of daphnia or the live food that is necessary for the well being of very small bass. In other words, fertilizer was not introduced directly in the bass ponds but was grown in a separate area, and then the natural food that was produced in this area by the use of fertilizer was transferred to the nursery ponds.

This year the Board had occasion to handle bass in waters that previously were heavily fertilized for the benefit of sunfish and catfish. This fertilized water, passing over the bass crop, developed two very interesting problems.

At the Tionesta Hatchery the crop of small-mouthed bass was supplied with water coming from a pond heavily fertilized. The Superintendent, Bernard Gill, noticed distress in these tanks of fish. He contacted the Board's Pathologist, Arthur Bradford, at the Fisheries Laboratory at the Bellefonte Hatchery. He immediately left for the Tionesta Hatchery; but by the time that he arrived, identified the organism, and worked out a curative measure, a heavy loss of fish had resulted.

From there, as a precaution, Mr. Bradford inspected the Union City and

Microscopic photograph of the active, living part of the bryozoan, or jelly-like mass.

Corry hatcheries. One battery of tanks that was fed from another fertilized pond was found to be slightly affected. Remedial measures were taken, and there was no serious loss. Had the men responsible for these fish crops not been keen observers and constantly on duty, the loss might have been disastrous.

For those interested, the bug that caused this difficulty has been identified as a protozoan parasite, Scyphidia tholiformis, not necessarily new to the pathologist; but this is the first time to our knowledge that it has reached a serious epidemic in the State Fish Hatcheries. This little protozoan is easily controlled by treating the fish in a 1/4000 formaldehyde solution for one hour.

To all appearances, these tiny organisms did not directly sap the life or strength from the fish, but they were

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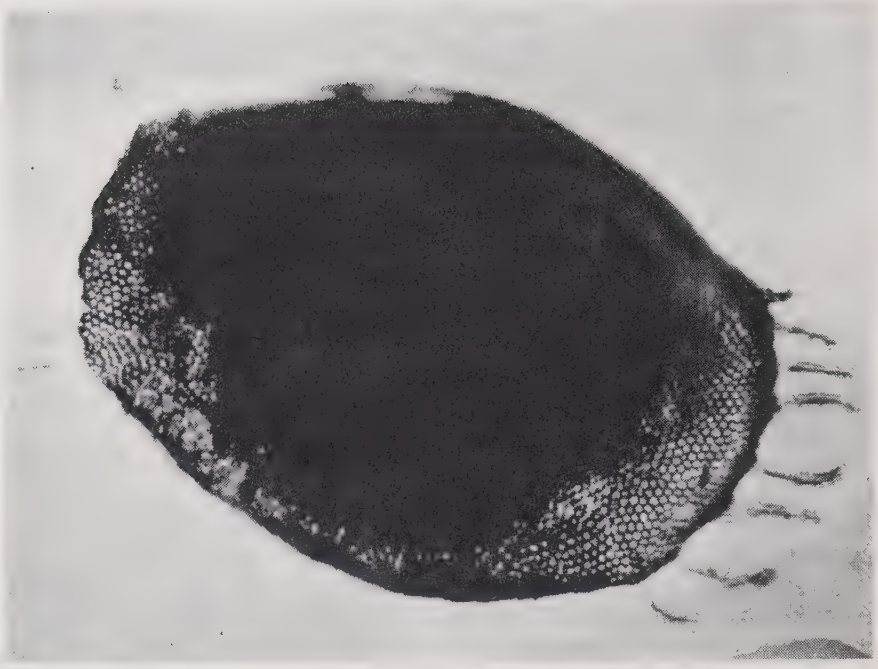
Reprinted, with illustrations, from Pennsylvania Angler 16 (12): 1, 14. December 1947.



A microscopic view of a seed-like mass of "statoblast" that is the reproductive body of the bryozoan.

present on the skin and gills in such great numbers that they set up an irritation that caused the fish to have a grayish, cottony appearance, followed by listlessness, loss of appetite, and possibly interference with respiration. The loss of appetite during the early growing period in late spring or early summer alone is serious to the bass as water temperatures are high, body activities are rapid, and the failure to take nourishment soon weakens the baby fish.

Somewhat similar circumstances occurred at the State Fish Hatchery at Pleasant Mount. Approximately 100,000 large- and small-mouthed black bass were being held in wire nursery boxes in a heavily fertilized pond. All during the growing season these bass showed normal growth and mortality. Small, jelly-like masses about the size of a quarter were observed as being attached to the wire meshes of the boxes, rocks, and decaying plant life where the boxes were suspended. Little significance was given to these organisms, as they appeared to be harmless to the fish and the fish appeared to feed in and about the organisms.

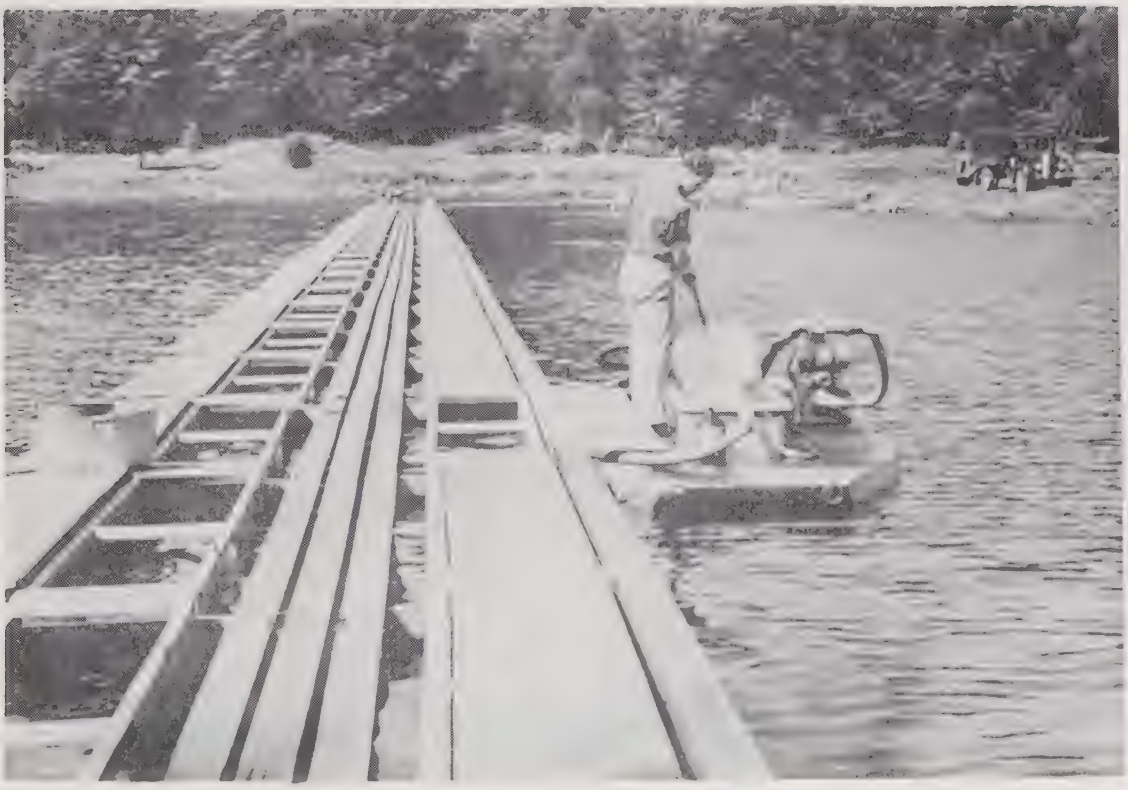
In early September, when the hatchery men started to remove the bass from the wire boxes, a high mortality occurred when the fish allotment was taken from the area. When the attendants noticed the distress of the fish, they ceased work immediately and sent for the hatchery superintendent, J. L. Zettle. Mr. Zettle noted that in removing the bass from the wire boxes the nets were crushing these jelly-like masses. He associated this with the loss of the fish.

The fish in the remainder of the boxes were removed in such a manner that these organisms were not disturbed. The pathologist, Mr. Bradford, again went to work on this problem, and he definitely proved that the crushing of these organisms is very toxic to fish. Apparently, when the organism is crushed, it throws off some liquid that is deadly to the fish. This jelly-like mass was recognized as belonging to the order of bryozoan, but the particular species to date has not been identified.

The men who manage and operate the fish-producing plants for the Board of Fish Commissioners are in an intense farming activity, and they learn to be about as ingenious as the average farmer in his work.

In the same pond where these boxes were carried was a large crop of catfish, yellow perch, and sunfish. Had these fish been removed in the conventional manner and these organisms crushed, it probably would have resulted in destroying a great portion of the year's work.

A wire nursery box used in growing bass.



A series of wire boxes, suspended in water, used in bass culture.

Electric fish screen in operation. Electrical impulses drive the fish ahead of the boat.

The results of the drive--a catch of various species of fish.

To offset this, an electronic fish-chasing device was developed by the Board's Engineer, Thomas F. O'Hara, and the fish were removed without seriously disturbing these organisms.

This electronic fish-chaser is not a Buck Rogers product. It is an offshoot of the Burkey Electric Screen. This electric screen is used to prevent the migration of fish. It throws off at very frequent intervals harmless electric impulses which will shock but will not paralyze. The sensation to a person within reach of the screen is similar to being pricked by many pins. We assume that it has a similar effect on the fish, as they rapidly get out of the way of these electric impulses.

An outfit, consisting of a 110-volt alternating current power plant and an electronic generator, was installed in a rowboat, with the electrodes suspended in the water from the bow of the boat. As the boat moved through the water, the electric impulses chased the fish ahead of it. That answered the purpose of conventional drag seining but did not disturb the organisms on the pond bottom.

ABSTRACTS

AMERICAN FISHERIES SOCIETY

THROUGH the courtesy of Dr. Russell P. Hunter (Secretary) and Dr. Ralph Hile (Chairman of the Editorial Board), we have been permitted to prepare the following abstracts of papers presented at the 77th Annual Meeting of the American Fisheries Society:

Cytophaga columnaris AS A CAUSE OF FISH EPIDEMICS

H. S. Davis
Oregon State Game Commission
Portland, Oregon

An epidemic that resulted in the death of large numbers of white crappies (Pomoxis annularis) in McKay Reservoir near Pendleton, Oregon, was found to be due to infection with Cytophaga columnaris, a myxobacterium. Extensive lesions produced by this organism were on the body and gills of dead and dying fish. Other epidemics are known to have been produced by C. columnaris, and it is suggested that during warm weather this organism may be a frequent cause of mortalities among fish in lakes and possibly in streams.

THE TOXICITY THRESHOLDS FOR THREE CHLORIDES AND THREE ACIDS TO THE FRY OF WHITEFISH (Coregonus clupeaformis) AND YELLOW PICKEREL (Stizostedion v. vitreum)

James O. Edmister
Franz Theodore Stone Laboratory
and
John W. Gray
Ohio Division of Conservation and Natural Resources
Put-in Bay, Ohio

On 24-hour-old fry of whitefish and yellow pickerel, experiments were run to determine the toxicity thresholds of sodium chloride, calcium chloride, potassium chloride, sulfuric acid, nitric acid, and hydrochloric acid in Lake Erie water.

The toxicity thresholds of these substances were determined as follows:

	Whitefish	Yellow pickerel
NaCl	16,500 ppm.	3,859 ppm.
KCl	10,368 ppm.	751 ppm.
$CaCl_2$	22,080 ppm.	12,060 ppm.
HCl	67.5 ppm.	67.5 ppm.
H_2SO_4	80.1 ppm.	71.2 ppm.
HNO_3	113.0 ppm.	98.5 ppm.

The toxicity thresholds of acids were approximately the same as those for Daphnia magna in Lake Erie water, as determined at this laboratory, and for fish examined by investigators elsewhere.

The fry of whitefish and yellow pickerel were usually much more tolerant to the salts than were Daphnia magna and the other fish species about which information was available.

FERTILITY OF BROWN TROUT (Salmo fario) OVA AT THE JONKERSHOEK INLAND FISH HATCHERY

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Cape of Good Hope
Stellenbosch, South Africa

This paper covers the findings of 10 years of research on the problem of the low fertility of brown trout (Salmo fario) ova at the Jonkershoek Inland Fish Hatchery, Stellenbosch. Included is a brief resume of the acclimatization of trout in South Africa, a process with which the development of the Jonkershoek Hatchery has been closely associated.

The investigation was begun with study of the artificial factors such as stripping, hatching-house technique, and diet. Thereafter, both male and female stock fish were thoroughly examined. Finally, a record was made of climatic conditions at Jonkershoek, as compared with other trout waters. The more important findings of this investigation were:

(1) The fertility of the ova was raised by a modification in stripping technique.

(2) There is a period of optimum fertility, at which stage the eggs should be stripped.

(3) The maximum mortality in any one batch of eggs may be expected on the ninth day after impregnation.

(4) The genital system of the male is normal, and the effective life of the milt in water does not exceed 40 seconds.

(5) The genital system of the female appears to be normal.

(6) Through improvement of the diet and regular feeding, the stock fish gain in condition, the yield of ova increases, and the eggs strip easily. Good feeding is as important for the cocks as for the hens.

(7) Though ecological factors such as stream flow and temperature are by no means optimum, none of the factors investigated presents a definite obstacle to the culture of trout.

Though the fertility of the eggs and general condition of the breeders have been improved, the problem is by no means solved. The mean is just over 80 percent, but fertilities of 98 percent have been recorded for individual batches.

WIDER APPLICATION OF THE ELECTRICAL METHOD OF COLLECTING FISH

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Missouri Conservation Commission
Columbia, Missouri

Limitations of the electrical-shock method of collecting fish, as commonly used, are reviewed. It is generally believed that the equipment considered necessary is cumbersome and costly; that the method is effective only on quite narrow, clear-water streams; that effectiveness varies greatly with chemical content of soil and water; and that it is dangerous. Equipment and techniques that overcome these limitations in some degree are described. It has been found that less and more simple equipment can be used effectively and safely. Methods which eliminate many time-consuming delays have been developed. Equipment and techniques that are effective on wider streams and in turbid waters are described. An electric "seine," fully effective in streams 90 to 100 feet wide, has been developed. It can be used quite effectively in wider streams; in turbid water the method is less efficient but a quite satisfactory sampling of the fish population can be made.

Informal experiments have been made on the amount of electric current needed to stun fish without killing them. Apparently, most species of fish may be stunned but will recover in a few minutes from shock caused by 5 to 6 amperes of alternating current at 110 volts. Larger

fish seem to be stunned more readily than fingerlings. Factors influencing efficiency are believed to be chiefly those involved in the recovery of stunned fish. Turbid water, swift current, and rough bottom seem to decrease efficiency. Experimental evidence on these points is incomplete and unconclusive, but evidently the method is very effective in sampling qualitatively areas which otherwise could not be worked.

AN ANALYSIS OF THE FEEDING HABITS OF RAINBOW TROUT AND LAKE TROUT IN BIRCH LAKE, CASS COUNTY, MICHIGAN

J. W. Leonard and F. A. Leonard
Michigan Department of Conservation
Ann Arbor, Michigan

In Birch Lake, an oligotrophic lake in southwestern Michigan, rainbow trout (Salmo gairdneri) and lake trout (Cristivomer namaycush) have been stocked at various times in an effort to make the deeper waters of the lake provide more fishing. Over a 6-year period, creel-census clerks collected stomachs of 322 rainbow trout and 25 lake trout taken by anglers. Analysis of the contents of these stomachs revealed that while the two species of trout were competing with each other for food, neither species preyed upon the indigenous cisco population nor competed with it for food. Aquatic insects and fish made up the greater part of the diet of both species of trout. The fish portion of the diet consisted largely of forage species, with yellow perch and centrarchids occurring but seldom in the stomachs. Rainbow trout took very little surface food except during late June, when there was a mass emergence of burrowing May flies, and in October and early November, when many terrestrial insects were consumed.

FROM OTHER SOURCES

EFFECT OF AIRPLANE DISTRIBUTED DDT THERMAL AEROSOLS ON FISH AND FISH FOOD ORGANISMS. A. O. Hess and G. G. Keener. Jour. Wildlife Mgt. 11 (1): 1-10 (1947).--Application of a thermal aersol DDT spray at rate of 0.1 pound DDT per acre to water areas, almost completely eliminated mosquitoes and surface Hemiptera, and it materially reduced the Coleoptera and amphipod crustacea. Apparently 16 applications per season of this aersol had no injurious effects on the fish population or other food organisms.

NOTA PRELIMINAR SOBRE A PRESERVAÇÃO DE ÕVULOS E ESPERMA DO PEIXE-REI DA AGUA DOCE, Odonthestes bonariensis VAL. Herman Kleerekoper. Boletin Agronomico (Brazil) 119-120: 291-293 (1946) (English summary).--The "peixe rei" is proving a valuable fish for stocking coastal lagoon waters. Adults are caught in gill nets and stripped immediately; they die shortly afterward. Dilutions of sperms were made in Salisbury's M/15 yolk-citrate mixture in proportions of 1:3 or 4. After 24 hours at 16° C., these sperms gave 60 percent fertility; after 48-hour storage, up to 40 percent. Eggs were preserved within the whole ovary for 24 hours by storage in a humid, tightly closed thermos flask at room temperature.

REPORT ON THE CAUSES OF THE DETERIORATION OF THE TROUT FISHING IN THE DIVISION OF MACLEAR, CAPE PROVINCE (1945-1946), WITH NOTES ON THE CONDITIONS AT MOUNT FLETCHER AND MATATIELE, EAST GRIQUALAND. A. C. Harrison. Union South Africa Inland Fish. Dept. Rpt. 3: 18-27 (1946).--The rainbow trout is well suited to the waters of Maclear. It is thoroughly acclimatized and prolific. The deterioration of the fishing is due to excessive land erosion

during recent years. Heavy mortality occurs during drought because the pools are filled with silt.

NUTRITION OF TROUT: STUDIES WITH PRACTICAL DIETS. B. A. McLaren, E. F. Herman, and C. A. Elvehjem. Prac. Soc. Expl. Biol. and Medicine 65 (1): 97-101 (1947).--Trout appears to be a carnivore. Liver is an adequate ration. Embody was unable to raise trout on mixture of plant and animal material. Stomach of trout with natural foods was high in protein and fat, low in carbohydrates. McCay utilized purified rations of the casein-sucrose type and found trout required fresh liver. Titcomb raised trout on mixtures of liver with fish and vegetable meals. Wilkinson found that that type of mixture raised rainbow, brook, and brown trout more economically than animal foods alone. Field reported vegetable meals, skim milk powder, gelatin, and concentrated liver fraction produced fair growth for a short period: growth ceased after 8 weeks but resumed if food was finely ground.

Ration C (modified from Field) contained:

Skim milk powder	25
Alfalfa leaf meal	10
Soybean oil meal	15
Liver A	10
Brewer's yeast	5
Iodized salt	0.5
Red dog flour[1]	22.5
Cod liver oil	2
Gelatin	10

[1]May substitute rolled oats finely ground.

This diet produced satisfactory growth in the laboratory and in the hatchery. For feeding in hatchery it was mixed with 1½ times its weight of water and allowed to set 40 minutes, until it had a firm, gelatinous consistency.

Feeds were used at rates of 2 to 6 percent of body weight per day.

USE OF FISH IN THE CONTROL OF BILHARZIA. D. Hey. Union South Africa Inland Fish. Dept. Rpt. 3: 17 (1946).--Work is in progress on the use of fish to eradicate the snails which are intermediate hosts of this disease. The European tench (Tinca vulgaris) will eradicate snails in permanent waters. The African lungfish (Protopterus) was imported for use in temporary ponds. Laboratory tests have shown that this species can live entirely on a snail diet.

EL CULTIVO DE PECES EN ESTANQUES ARTIFICIALES. J. Alvarez. Revista de la Sociedad Mexicana de Historia Natural 7 (1-4): 75-85 (1946).--Great possibilities exist for the construction and operation of ponds for fish production in Mexico. The limnological factors affecting pond productivity are discussed, and results with bluegill-bass combinations in the United States are given. The author concludes that it is very probable that there are Mexican species better adapted to cultivation in ponds than the above-mentioned combination. An experimental station should be established to determine the value of Mexican species in fish culture.

RECEIVED IN

CLEARING HOUSE

Experiments on pond fertilization.
H. S. Swingle.
Ala. Exp. Sta. Bull. 264, 34 pp.
November 1947.
(Alabama Polytechnic Institute, Auburn, Alabama.)

Fish ponds for the farm. F. C. Edminster.
114 pp., illus. $3.50.
(Charles Scribner's Sons, New York.)

The culture of freshwater fish in South Africa. D. Hey.
124 pp., illus. rev. ed. 1947.
(Inland Fisheries Department, Provincial Administration of Cape of Good Hope, Stellenbosch, South Africa.)

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